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ENVIRONMENTAL IMPACT ASSESSMENT IN THE U.K.: ITS CURRENT STATUS IN THE LIGHT OF THE PROPOSED E.E.C. DIRECTIVE

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1. INTRODUCTION

Within the past two decades there has been a growing concern in the United Kingdom about the effects of new development on the quality of the environment and the ability of the planning system to take these effects into account, not only at the project submission stage (development control), but also in the context of plan formulation (forward planning). Encroachment on the countryside by new and expanded towns, motorways and industry has been a significant factor in increasing public anxiety regarding the implications of development. The concern is by no means new, but until recently the projects which have aroused opposition have been intermittent and geographically dispersed. Since the discovery of dry gas in the southern part of the North Sea in 1965, and the discovery of oil and gas beneath the North Sea off the Scottish coast in 1970 this has no longer been the case.

It is against this background that Environmental Impact Assessment (EIA) has evolved in the UK. The term EIA stems from the US National Environmental Policy Act 1969, which requires analysis of the environmental impacts of major federal actions significantly affecting the quality of the human environment in the form of an "environmental impact statement" (EIS). An EIS must cover the following topics:

(a) the environmental impact of the proposed action
(b) any adverse environmental effects which cannot be avoided should the proposal be implemented
(c) alternatives to the proposed action
(d) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity
(e) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Since the passing of the Act much has been written about the advantages and disadvantages of EIA. Proponents argue that it has led to a systematic, comprehensive consideration of environmental impacts, to positive public participation in the decision-making process and to a greater awareness of the need to enhance environmental quality. Critics stress the costs and delays that the new legal system has introduced, the collection and analysis of irrelevant information and the development of methods which hinder or confuse the identification of key issues by the decision-maker. It is not the purpose of this paper to consider the United States' system as this has been documented elsewhere (1) but in reviewing the current status of EIA in the UK it is necessary to be aware of the great debate which is taking place, not only in the United States, but also in many other countries that are adopting some form of EIA, about the potential role of EIA as a policy instrument to enhance the quality of the environment. The role of EIA as a policy instrument in the UK is now an even more controversial topic as a result of draft proposals by the EEC to introduce a mandatory system of EIA for certain specified types of projects.

It is important to stress that there is no general and universally accepted definition of EIA. The following examples selected from a number of authorities illustrate the great diversity of definitions which exist:

(i) "... an activity designed to identify and predict the impact on man's health and well being, of legislative proposals, policies, programmes and operation procedures, and to interpret and communicate information about the impacts" (2).

(ii) "... an assessment of all relevant environmental and resulting social effects which would result from a project" (3).

(iii) "... assessment consists in establishing quantitative values for selected parameters which indicate the quality of the environment, before, during and after the action" (4).

In this paper EIA is taken to mean the systematic examination of the environmental consequences of projects, policies, plans and programmes. Its main objective is to provide decision-makers with an account of the implications of alternative courses of action before a decision is made. The results of the assessment are assembled into a document referred to as an EIS. When an EIS has been prepared it is used by decision-makers as a contribution to the information base upon which a decision is made. In the UK the term "project appraisal" is often used in preference to environmental assessment.

It is suggested that EIA should not be thought of as some kind of scientific "black box" which produces definitive answers. Instead it should be thought of as a concept which allows decision-makers to be made aware of likely impacts should a proposal proceed. Whether or not it does proceed may be influenced by factors such as energy needs, employment levels or technological necessity, which legitimately may have greater priority at any given place or time. In these circumstances EIA may indicate mitigating actions or the type of monitoring which should take place. It may also allow various "trade offs" between competing objectives to be more fully understood.

The paper will consider the development of EIA in the United Kingdom. Whilst most emphasis will be placed on the appraisal of projects, mention will be made of the EIA of policies and plans which is now receiving greater attention. There then follows a section on the attitude of developers towards EIA. The final section of the paper will consider the proposed E.E.C. draft directive concerning the assessment of the environmental effects of certain public and private projects (5). Future prospects for the development of EIA in Britain will be evaluated in the light of the current negotiations now taking place on the directive.

2. THE DEVELOPMENT OF EIA IN THE UNITED KINGDOM

EARLY DEVELOPMENTS

Since the Town and Country Planning Act became law in 1947, UK planners have gained considerable experience of the assessment of the likely consequences of major development proposals. From the late 1960s, however, the UK has witnessed an upsurge in public concern for the protection and enhancement of the environment. There can be no doubt that this concern about environmental matters has intensified public interest in the impact of major developments.

In this context, the proposal to build a third London airport in south-eastern England can be considered a watershed. Considerable time and resources were spent in adapting cost/benefit analysis to measuring environmental and social impacts. It can be argued that the appraisal of the third London airport constituted the first UK attempt to implement an environmental impact assessment of a major development proposal. However, the problems involved in using cost/benefit analysis in project appraisal led to a realisation that other assessment methods were required if a balanced appraisal of likely environmental and social impacts were to be achieved.

Although the third London airport proposal was an important event in the history of project appraisal in the UK, the main impetus resulted from the discovery of North Sea oil and gas. The extraction of oil and gas requires large production platforms whose construction necessitates access to deep water. As exploration and production moved to the north of the North Sea oil province, planning authorities in North Scotland began to receive applications for platform construction sites. Most of these sites were situated in areas noted for their outstanding visual quality containing small rural communities characterised by a distinctive way of life. In many cases planning authorities were unfamiliar with the characteristics of platform construction yards and often did not possess the resources to undertake thorough appraisal of the development.

To help overcome some of these problems, the Scottish Development Department (SDD) issued an advice note to planning authorities entitled "Appraisal of the Impact of

Oil-Related Development". This note pointed out that oil-related developments need "... rigorous appraisal". Significantly, it also stated that other non-oil related "... large-scale and unusual projects ..." require similar attention. This was the first recognition by a UK central government department that major developments necessitated special appraisal if the UK planning system were to meet the demands of developers and the public. The advice note provided a suggested approach to the assessment of major proposals. One of the components of the approach was the commissioning of an impact study, by a planning authority, if it was considered necessary.

From 1973 onwards, a number of environmental impact studies of major oil developments have been undertaken (6). Many were financed jointly by the Scottish Development Department and planning authorities and carried out by independent consultants whilst others were financed by developers. Reports presenting the results of these impact studies are similar, in many respects, to the EISs prepared in the US under the National Environmental Policy Act of 1969. These reports were initiated on an ad hoc basis and not as a mandatory planning requirement.

As well as oil-related impact studies a number of other impact assessments were initiated in the 1970s. These include a study for the NCB in connection with its proposal to mine coal in the Vale of Belvoir, an EIA for the Craigroyston pumped storage electricity scheme at Loch Lomond and a number of EISs of motorway and trunk road proposals. Again it should be noted that these studies were not a mandatory requirement.

Experience of assessing platform sites, the likelihood of major oil and gas developments and other types of large-scale developments showed that various aspects of project appraisal required investigation. Central government took the initiative and set up two separate, but complementary studies to investigate certain aspects of project appraisal. In 1973, Project Appraisal for Development Control (PADC) research team at the University of Aberdeen, was commissioned to prepare a Manual to assist planners assess the environmental impacts of major industrial developments. The appraisal procedure developed was published as "The Assessment of Major Industrial Applications - A Manual" and issued as an interim report to all UK planning authorities (7). A revised, extended and updated version of the Manual has now been prepared (8).

In 1974, the Secretaries of State for the Environment, Scotland and Wales commissioned an investigation into the "... desirability of introducing a system of impact analysis in Great Britain, the circumstances in which a system should apply, the projects it should cover and the way in which it might be incorporated into the development control system under the Town and Country Planning Acts as it applies to both private and public sector development." (9). The report is concerned with making recommendations on such topics as the identification of those responsible for carrying out project appraisals and preparing impact statements, payment procedures and legislative changes which might be required. The PADC Manual does not deal with these topics. It contains an assessment method which enables local authority planners to carry out project appraisals within the existing UK development control system (Fig. 1). The Catlow/Thirlwall report explicitly considers the appraisal of both public and private sector developments within the overall system for environmental impact analysis advocated. Although the method in the PADC report can be used by local authority planners to appraise public sector developments, it is primarily directed at private sector developments.

NATIONAL PLANNING GUIDELINES

One area where EIA is increasingly being used is in forward planning in Scotland with the concept being developed by central government through National Planning Guidelines (10) The guidelines circular described their function as defining the level at which there was a "national interest" in development control matters, but it also made clear that development control could not be considered independently of development planning. The guidelines also contained suggestions for positive action. In the guidelines on "Sites for Large-Scale Industry" site selection criteria were set out together with an indication of the areas most likely to meet the criteria. Planning authorities were encouraged to examine the potential for large-scale industry in these areas and to frame their plans and development control policies accordingly. Similarly the guidelines for petrochemical developments stated that it would be prudent for planning authorities to establish the potential for petrochemical developments in their area and to frame their structure plans, local plans and development control policies so that sites can be readily identified if and when required. In both cases environmental assessment has become an important part of the evaluation procedures undertaken and this will be illustrated by looking at the example of forward contingency planning for petrochemicals (11).

The development of the North Sea offshore petroleum reserves has already led to demands for land, labour and infrastructure, with consequent environmental, social and economic impacts. As development moves into the production stage the opportunities created by these resources are of increasing significance in areas of Scotland which are not at present major centres of oil and gas related activity. Experience suggests that the ability of Central and Local Government to influence development in these areas is dependent on many factors but not least upon a continuous information flow and forward assessments of changing capacity and capability, and the desirability of, development in particular areas. The formal background to this work was reinforced by the National Planning Guideline for Petrochemical Developments issued in 1977, and the seven mainland regions most concerned with contingency planning for petrochemicals now have a fairly well developed appreciation of the potential and environmental capacity in their respective areas.

The terms of reference, approach and methods adopted by the regional working groups which were established to produce contingency plans have differed according to local conditions, attitudes and the availabilty of information. In some cases, the initial approach has been purely from a technical standpoint whereas other approaches have been tempered by political considerations. The working groups have carried out, or been associated with, studies aimed at establishing the physical and environmenta capacity for petrochemical development within their area and to date forty-six search areas have been examined. Some of the regional authorities concerned have commissione consultants to undertake special studies ranging from the economics of feedstock and product transport to site selection criteria, environmental capacity and safety aspec

Through the application of a blend of site suitability, constraints to development and local authority policy, the original list of forty-six sites has been refined and reduced to thirteen which are thought to have the requisite potential to support petrochemical development. On present evidence, most of the thirteen sites will be presented in structure plan submissions. The establishm of thirteen preferred petrochemical sites form the original forty-six does not mean that the residual thirty-three site have no industrial potential for several of the sites were identified as being suitable for large-scale non-petrochemical development.

It is of interest to note that conclusions drawn from the environmental assessments have led to a more comprehens review of alternative sites appropriate in environmental terms for petrochemical development. The preliminary application of the environmental assessments was clearly of value, in that at a very early stage it was possible to identify the main environmental impediments to the use of the identified sites for petrochemical development. Of no less importance is the need to carry this work forward to promote an atmosphere in which industrialists can invest freely in new capacity or add to existing facilities, yet at the same time ensure that the interests of the public and environmentalists have been taken fully into account.

CONTINGENCY PLANNING

Whilst this type of approach has not been so fully developed in England and Wales, the concept of developing what might be described as ad hoc contingency plans is a noticeable trend. Examples include work done by Gwynedd County Council in their assessment of sites for power station development and studies by Cheshire County Council concerning petrochemical developments.

In the case of Cheshire, the County Council were faced with the future expansion of the existing petrochemical complex at Stanlow. Three sites in the vicinity of Stanlow could be developed for petrochemicals and these were the subject of a special study, the Mersey Marshes Study. They decided to formulate a statutory local plan to deal with the special problems of expansion. One of the objectives of the plan was the selection of the most appropriate site for expected petrochemical developments. Another aim was to appraise the existing effect of the Stanlow complex on the environment in order to enable the assessment of future development applications to be carried out against an accurate picture of existing environmental quality and standards. Although a great deal of environmental information on the environs of Stanlow exists, and some tentative conclusions on the impact of the existing complex have been reached, Cheshire County Council realised that individual applications should still be appraised to ensure that planning decisions were based on sufficient information concerning likely effects.

It is hoped that the local plan, once finalized, will bear directly on the nature, type, extent and cost of individual project appraisals carried out for future projects. Those developments for which some advance knowledge exists will be assessed, in part, as a component of the plan-making exercise. Although obtaining information on expecte developments was not entirely successful, some information was obtained to enable future project appraisals for these developments to be less time-consuming and lengthy than might otherwise have been the case. This benefit of the local plan will affect, also, the project appraisals which may be implemented for other, unexpected developments Despite the fact that no preliminary, provisional assessmen will have been undertaken as part of the local plan, information on the local environment already obtained will ensure that these appraisals will not require lengthy periods spent obtaining baseline environmental data.

Cheshire County Council believe that the findings of the local plan will have an effect on the actions of the companies most likely to expand at Stanlow. Companies may tailor their proposals to fit as closely as possible. If they do so, it could be to their advantage as the time period for processing applications should be reduced becaus of the work already undertaken in preparing the plan.

LONG-TERM STRATEGIC PLANNING

An excellent example of the role of EIA in helping formulat long-term strategic plans is the study undertaken by Land Use Consultants for the North West Water Authority (NWWA). NWWA wished to decide on preferred alternatives for inclusion in the long-term strategic plan for water supply in the north west of England.

The purpose of the EIA was to identify the environmental impacts which would be incurred by reservoir development at one of four short-listed sites so that the Authority would be in a position to weigh environmental costs and benefits at each site against the technical feasibility and economic cost of providing the next increment in the region's water supply. The Environmental studies were undertaken by the Consultants and the Authority's own staff, with support from the staff of the seven Structure Planning Authorities in the region, and certain government agencies. These studies paralleled and formed an integral part of the engineering design studies.

In the course of the study, more than fifty variants were considered for the four basic schemes, and by the end of the process these had been reduced to fourteen viable alternatives, most of which had been shown to incur the least environmental impact while maintaining engineering benefits. Each of the fourteen short-listed variants were described in considerable depth in environmental and engineering reports. Following their publication a nine month programme of consultation took place with statutory authorities, government departments, and local interest groups. The views of all these bodies were subsequently reported to the Water Authority and in December 1979 the Authority announced that it had decided to drop one of the four alternative reservoir sites (Hellifield) in the light of the strength of environmental objections to its development.

No decision was taken on the remaining sites although the previously unsuspected high environmental costs of developing bunded storage in Morecambe Bay were noted. When linked to the high development costs it was concluded that development in Morecambe Bay did not appear to be an attractive option for inclusion in the Authority's strategy for future water resource development.

It would appear that the NWWA study indicates the benefits that can be achieved when joint assessment between the developer and other interested parties takes place before a particular site or project design is selected. The EIS indicates a particular site and project design option which has least harmful environmental impacts and this knowledge will save time, money and resources to both the developer and planning authority, if and when a firm proposal to proceed with a water-storage scheme is received by the planning authority. Time and resources will be saved, also, as feasible alternatives and their impacts have been examined in detail for expected impacts.

3. ATTITUDES OF DEVELOPERS TO EIA

In general developers in the United Kingdom are not enthusiastic about the concept of EIA, but particularly as there is now talk of making it mandatory. The main reason appears to be that it is believed that additional costs and delays would be incurred. It is argued that the existing planning system and pollution control measures adequately take account of environmental considerations when planning permission is being considered or when conditions are imposed before a plant becomes operational. The CBI, however, does accept "that in the few cases of major development where several features would impact in a significant way on the environment, it is reasonable to propose that all the facets should be brought together in a more comprehensive appraisal of the total impact. The CBI believes that the UK framework provides for full public representation and commonly in the case of major projects for enquiry into alternative locations" (

In general the CBI believes that real harm would result from the introduction of mandatory formal environmental impact assessment procedures for specified type of project. In particular:

(a) an undesirable rigidity would be introduced in the planning system and the analysis could be taken as an infallible basis for correct planning decisions even though the possible effects on the environment cannot be forecasted precisely

(b) inevitably duplication of effort between the pollution control and the planning authorities would occur

(c) further delays in the already overburdened planning procedures would be inevitable

(d) few, if any, authorities have or could maintain resources or expertise, or access thereto, to analyse even more data (12).

Although the main purpose of EIA is to prevent developments taking place which would unacceptably harm the environment, some industrialists have argued that an EIS can serve their interests. In a recent interview Jack Birks, the Managing Director of BP stated that "One thing we have learned from our international experience is the value of EIS, anticipating well ahead of the activity what the environmental consequences might be". He went on to say that an early Shetland EIS was invaluable in enabling BP to proceed with the Sullom Voe oil terminal (13).

BP has a formal internal system of EIS for all major new developments. An EIS is prepared by the associate or subsidary company proposing the development and submitted to the Group's central Environmental Control Centre. Endorsement by the Environmental Control Centre is required for planned capital investments of more than £5m. It is claimed that environmental considerations are taken into account at every stage of design of a major development and in advance of a planning application being made. BP benefits from speedier processing of planning applications, from avoidance of unnecessary conflicts on conservation grounds, and from the reduced risk of delay or disruption arising from lengthy and costly public hearings (14).

The British Gas Industry has also found EIS to be a valuable tool in project planning and has developed a number of methods of appraisal, particularly on visual impact analysis. Frank Dean, Chief Environmental

Planning Officer of the British Gas Corporation, accepts that the preparation of an EIA is a time consuming and expensive operation but believes that it produces significant advantages. "Firstly, it is unquestionable that in the end, a much better designed and sited installation will result and this will have a long-term financial advantage. Secondly, the increasing awareness of the general public of the need for care and protection of the environment and the growing practice of planning authorities of involving the public in the decision-making process could and does lead to serious delays in obtaining the necessary consents. If an environmental impact analysis has been carried out, it will demonstrate to all that the decision to develop at a certain place and in a certain manner has not been lightly taken and this should reduce the overall time for the project to be completed, with a consequent saving in costs" (15).

Both BP and British Gas recognise the value of EIS as an inseparable part of project planning which ensures that environmental factors are given full weight. By integrating the environmental considerations at the outset, objections and delays at later stages may be avoided. The preparation of an EIS by a planning authority on receipt of a planning application serves a different purpose of informing decision-makers and the public. Nevertheless, the same advantages of undertaking a comprehensive appraisal as early as possible to pre-empt later delays apply. An EIS may reveal an adverse impact that can be avoided by modifying the proposal but which were it not to come to light until a later stage, perhaps at a public inquiry, would cause significant delays.

4. DRAFT DIRECTIVE CONCERNING THE ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF CERTAIN PUBLIC AND PRIVATE PROJECTS

It is clear from the evidence presented so far that in the

UK, EIA is evolving not only in an ad hoc and informal manner, but also as an adjunct to the existing land use planning process. It is the draft EEC Directive, which would make the assessment of certain types of proposed projects mandatory, that has led to much of the current interest, and in some instances hostility towards, environmental assessment. This section will describe what the Directive proposes and then consider the markedly different stances being adopted by various interest groups. Stances which see the government of the day, many industrialists and local authority associations opposed, either in principle or in detail, to the Directive as it now stands but with strong support being expressed by the Select Committee on the European Communities of the House of Lords, the Royal Town Planning Institute and many environmental groups.

THE DRAFT DIRECTIVE

The aim of the draft directive is to introduce a common procedural framework to ensure that environmental factors are adequately considered by "competent authorities" taken to mean central and local planning authorities of Member States, in decisions concerning the authorization of certain development projects.

The legal basis for the draft directive is said to be Article 100 of the EEC Treaty, under which the Council may adopt directives for the approximation of laws which directly affect the establishment or functioning of the common market. The preamble to the draft directive claims that "a significant disparity between measures in force in the various Member States with regard to the assessment of environmental effects may create unfavourable conditions and thereby directly affect the functioning of the common market (5).

The principal provision of the draft directive lays down that "before any planning permission is given, projects likely to have a significant effect on the environment" are to be "made subject to an appropriate assessment of these effects". There are no quantitative thresholds laid down for determining which projects are likely to have such an effect. Instead, the types of project which may require an assessment are listed in two annexes. Annex 1 lists 35 classes of development which "shall be made subject to an assessment" (Article 4(1)). Annex 2 lists a further 43 classes of project which are to be made subject to an assessment "whenever their characteristics so require" (Article 4(2)).

There is provision, under Article 4(1), for excluding certain Annex 1 projects from an assessment. The provision applies to "exceptional cases which are unlikely to have any significant effect on the environment". In such cases, the competent authority "may, with the agreement of the Commission, exempt a particular project below a specified threshold from the assessment mentioned above and, where appropriate, make it subject to a simplified form of assessment" (Article 4(1)). No definition is given of this "simplified form of assessment". In the case of Annex 2 projects, the criteria and thresholds for determining whether an assessment, or a simplified assessme is necessary are to be a matter for the competent authority (Article 4(2)). However, Member States are to inform the Commission of the criteria and thresholds adopted, and the Commission is to review them regularly "with a view to ensuring consistency in the application of the Directive (Article 5). Projects not listed in Annexes 1 and 2 are to be subject to an assessment or a simplified form of assessment where they "are likely to have a significant effect on the environment, having regard in particular to the environmental sensitivity of the site" (Article 4(3) Member States are to inform the Commission of the criteria and thresholds which they adopt (Article 5).

Where a proposed project requires an assessment under the draft directive, the developer must, under Article 6(1) prepare (with the assistance of the competent authority when necessary) information in an appropriate form. Annex 3 indicates more fully the data required. These data are to be included "to the extent that they are relevant to the stage of the planning procedure and to the specific characteristics of the project and of the environment likely to be affected, and to the extent that the developer can reasonably be expected to be able to obtain them, taking into account existing knowledge and assessment methods" (Article 6(2)).

When an assessment is required, it is for the developer to supply the appropriate information with his application for planning permission. The competent authority then has to send for opinion the application and the information to "all relevant administrative authorities and other statutory authorities or bodies with specific responsibility for environmental matters" (Article 7(1)). It must also send the information to the competent authority in any other Member State in which the project is likely to produce a significant effect on the environment (Article 7 (2)). It must also make the documents publicly available and arrange appropriate public consultation. It is for the competent authority to decide "the best means for giving information to the public within a suitable time limit and for ascertaining the views of the public" (Article 8). These requirements are subject to the need for limitations to protect industrial and commercial secrecy, and the public interest (Article 9).

While it is the primary responsibility of the developer to obtain the necessary information, it is for the competent authority to provide assistance when necessary. There is also provision for the competent authority to "require completion of, or assist in completing when appropriate, the information to be supplied by the developer" (Article 6(3)). When deciding on an application for planning permission, the competent authority is to "take into consideration" the information gathered under Article 6 and from subsequent consultation, and to that end is required to "make an assessment of the likely significant effects of the proposed project" (Article 10(1)). Except when planning permission is refused on grounds other than environmental, the competent authority is to make available with its decision, or as part of the decisio its assessment of the likely significant effects on the environment of the proposed project, a synthesis of the main comments and opinions received, the reasons for granting or refusing the planning permission, and the conditions, if any, to be attached to the planning permission (Article 10(2)). Subsequent to a grant of planning permission subject to conditions, the competent authority is to check periodically whether the conditions are being complied with, whether they are still adequate, whether other provisions to protect the environment are being obeyed, and whether it needs to take further measures to protect the environment from the effects of the project (Article 11).

THE DRAFT DIRECTIVE; CURRENT DISCUSSIONS

During the past few months the draft directive, which was forwarded to the Council by the Commission on 16 June 1980 has been under consideration by a number of European institutions who have to express their views before Council can make a decision. This includes both the European Parliaments Environment Committee and the Legal Affairs Committee and the Economic and Social Committee of the Community. Perhaps of greater significance is the debate taking place in the working group established by the Committee of Permanent Representatives (COREPER) to help advise the Council, This stage is critical in that it involves detailed negotiations between civil servants from the ministries concerned with the environment of the Member States. Much of this ongoing debate is secret in nature and the ability of interested organizations to inform or be informed is severely limited. It is a process whereby a considerable amount of 'horse trading' between civil servants of Member States appears to take place as countries try to impose their own views about the directive. It is clear that there is opposition in several quarters to the directive, but whether this opposition is in principle or in detail is still a matter of conjecture.

Within the UK itself attitudes towards the draft directive whilst clearly divided are at least more explicit. All the evidence available suggests that the current government takes a cautious line to the directive as it now stands. Whilst accepting that environmental assessment is a good thing per se they have argued on a number of recent occasions that a mandatory directive would not be in the interest of the UK (16) (17). Specifically they are strongly opposed to the concept of the arbitrary nature of listing developments in Annexes and the extra possibilities for litigation and hence additional costs and delays that this might incur. The current informal use of EIA in the UK, practical, pragmatic and supplementary to the existing land use planning system, is considered far more acceptable.

In their approach there can be no doubt that the government have very powerful allies. They include many sectors of British industry, and also most of the Local Authority Associations. Much of the opposition is centred on the belief that the UK already has a very sound system of development control and that other European countries that have a weaker system should attempt to put their own house in order and not rely on mandatory assessment, which it has been argued, would penalize British industry. An extreme view on this is seen in the comment of one witness representing the Association of County Councils when giving evidence about the draft directive to the House of Lords Select Committee on the European Communities "I am not convinced that the British people will welcome a directive if it is only to put the affairs of Europe right. Europe must learn from us. They copied us in order to have Parliament like ours so perhaps they had better adopt our planning system....... I am arguing we do not want a Directive at all..."(16). The Labour party when in power were also somewhat cool towards EIA and this is still clearly the case as witnessed by the comments made by Labour M.P.s during the House of Commons debate on the directive in the First Standing Committee on European Community Documents (17).

Elsewhere in the UK attitudes towards the draft directive appear more favourable. Perhaps the greatest amount of evidence has been acquired by the House of Lords Select Committee on the European Communities. This all party group of peers is in general strongly in favour of the directive. In the light of the evidence presented to the Select Committee they argue that the principle and practicality of the directive is sound and that with a number of minor modifications it should help, rather than hinder environmentally sound decision making within the UK and European Community in general. In this they have strong support from the Royal Town Planning Institute and also from the few people, whether they be local authority planners or environmental consultants, who have had practical experience of conducting environmental assessments. There is no doubt, however, that the views of the proponents of EIA, who argue that a mandatory system would be acceptable in principle, have had very little influence on either government Ministers or civil servants.

5 CONCLUSIONS

Many points of interest, indeed some would say of concern, have arisen during the ongoing debate on the draft directiv We have a number of practical issues which as yet have generated a number of unanswered questions. These include the following.

Should the onus be on a developer to prepare an EIA, albeit in co-operation with "competent authorities", or should prime responsibility rest with decision-making authorities whether they be local or central government? Should a developer be expected to incorporate his interpretation of planning policies for a proposed development site in his EIA? Will the public have full confidence in an

EIA prepared by a developer and accept it as a balanced assessment of both beneficial and adverse impacts? Will a mandatory list of projects which in all circumstances must be subject to EIA lead to an EIA system which may be legally sound and enforceable in all Member Countries but which nevertheless may generate unnecessary EIAs, raise irrelevant issues, collect unnecessary data and in the long-term do little to enhance or maintain the quality of the environment?

In the light of the above evidence it is difficult to draw anything but the most tentative conclusions about the current or future state of environmental impact assessment in the UK. Indeed, in a period when there is considerable debate, and uncertainty, about the future role of EIA, it is perhaps best not to draw any firm conclusions as these may be overtaken by events. There can be no doubting, however, that with increasing public interest in environmental protection, the impact of a proposed development on the environment has become a significant factor in determining whether or not it will succeed. Projects which are expected to have a detrimental effect may be delayed by objections and in the end may have to be abandoned. The need for more information about the effects of major installations on the environment has, therefore, been instrumental in the development of procedures of impact appraisal. EIA may be used by authorizing or funding agencies to determine whether developments should proceed. In these circumstances the appraisal would be undertaken when the planning of the project is well advanced. EIA also has a role earlier in the project planning process when used by developers to ensure that environmental issues are considered at an early stage. The image of EIA as a slow, bureaucratic procedure is largely based on the years immediately following the implementation of NEPA in the US. As experience has been gained in the US and UK, the value of EIA as a planning tool has been recognised. In response to demands for more effective assessment of projects, plans and policies, EIA is likely to play an increasingly important role in the

UK planning system. Whether, however, this is as part of a mandatory system or an informal ad hoc arrangement remains to be seen!

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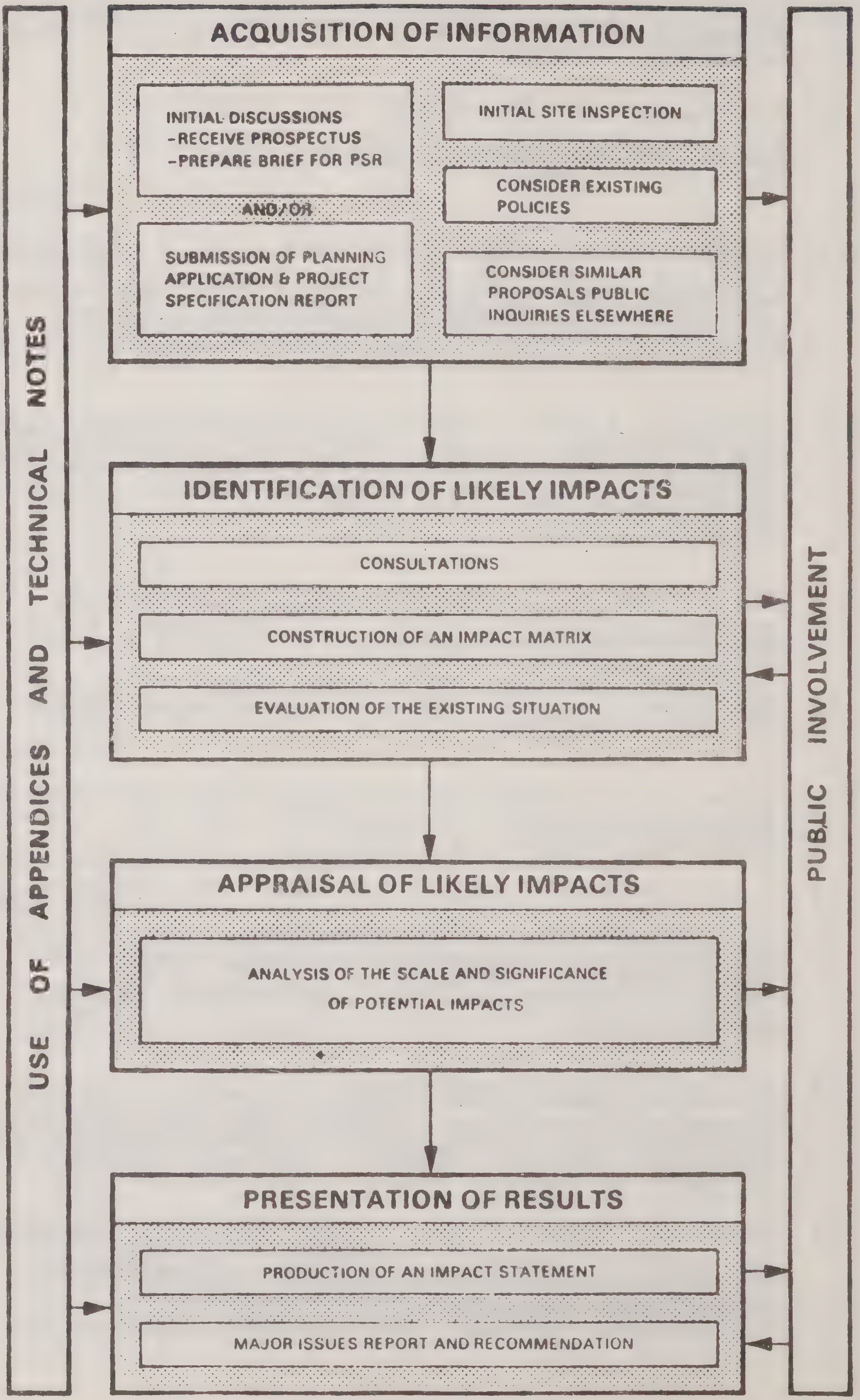
ACQUISITION OF INFORMATION
INITIAL DISCUSSIONS
-RECEIVE PROSPECTUS
-PREPARE BRIEF FOR PSR
AND/OR
SUBMISSION OF PLANNING APPLICATION & PROJECT SPECIFICATION REPORT
INITIAL SITE INSPECTION
CONSIDER EXISTING POLICIES
CONSIDER SIMILAR PROPOSALS PUBLIC INQUIRIES ELSEWHERE
IDENTIFICATION OF LIKELY IMPACTS
CONSULTATIONS
CONSTRUCTION OF AN IMPACT MATRIX
EVALUATION OF THE EXISTING SITUATION
APPRAISAL OF LIKELY IMPACTS
ANALYSIS OF THE SCALE AND SIGNIFICANCE OF POTENTIAL IMPACTS
PRESENTATION OF RESULTS
PRODUCTION OF AN IMPACT STATEMENT
MAJOR ISSUES REPORT AND RECOMMENDATION
USE OF APPENDICES AND TECHNICAL NOTES
PUBLIC INVOLVEMENT

Figure 1 *LINKED ACTIVITIES IN THE APPRAISAL METHOD*

NATIONAL SOCIETY FOR CLEAN AIR

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BRIGHTON

ENVIRONMENTAL IMPACT ASSESSMENTS - THE PLANNING CASE

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For rather more than thirty years now the planning legislation of this country has required that with few exceptions any proposal for development should be the subject of an application to the local planning authority for planning permission. 'Development' in this case has a very wide meaning; in the words of the Town and Country Planning Act, 1971 it means "the carrying out of building, engineering, mining or other operations in, on, over or under land, or the making of any material change in the use of any buildings or other land".

The local planning authority must determine the planning application in one of three ways. They may grant permission unconditionally, grant permission subject to such conditions as they think fit, or they may refuse permission. In dealing with the application the authority must have regard to the provisions of the development plan and to any other material considerations. Any condition imposed can only be one which is expedient for the purposes of or in connection with the development. In the case of either conditional approval or of refusal reasons for the conditions or for the refusal have to be given in writing by the local planning authority, and an aggrieved applicant has a right of appeal to the Secretary of State for the Environment.

Under the planning legislation, major and contentious planning applications invariably have to be advertised in the Press and by the display of notices on site. In common with all planning applications, large and small, the applications have to be available for public inspection at the offices of the local planning authorities. Many planning authorities go beyond what is statutorily required by way of advertisement of applications and most of them debate and take their planning decisions in public.

Often the decisions on these major contentious developments are taken ultimately by the Secretary of State for the Environment because the applicant may have appealed against a refusal decision by the local planning authority, or the development is contrary to the development plan, or the Secretary of State has called-in the application for his own decision. Usually, the Secretary of State will reach a decision on these major matters only after a Local Public Inquiry has been held under an inspector appointed by and reporting to him. In determining an application which has been advertised in accordance with the Planning Act, the Secretary of State - and usually prior to that, the local planning authority - must take into account any representations which are made and which relate to the application.

It is against this necessarily brief outline of the control of development under the Planning Acts in this country that I propose to consider Environmental Impact Assessment. EIA is an approach to the control of development which originated in the United States. There, the planning legislation is far less developed than in this country, and the EIA legislation was a response to growing public concern at the damaging effects of some of the major developments which were taking place. It applied originally only to Federal proposals, but is increasingly being applied to State proposals, and doubtless will be applied to major private developments. An Impact Statement has to be prepared and made public for proposals which significantly affect the quality of the human environment.

An Environmental Impact Assessment is in effect a balance sheet of the anticipated results and the effects of a proposal. In its widest application EIA covers not only the effects on the physical environment such as pollution of air and water, noise, impact on the landscape, and traffic consequences, but also deals with such matters as the likely direct economic effects of a proposal, 'spin-off' economic effects, and increased housing, shopping, schooling and recreation demands. It is in this widest sense that I shall consider EIA and it is when it is viewed in this widest way that I consider EIA to have its greatest value. Its value and purpose is, of course, in the extent to which it results in a greater public knowledge of the nature and effects of a proposal and in a better informed and more objective decision.

Over the past few years the EEC has been seeking to direct its member states statutorily to require the preparation and submission of an Environmental Impact Assessment for any proposal comprised in a defined range of developments. As in the USA, this is largely a response to public disquiet at the effects of some of the developments which have taken place in member states, which do not have the tight statutory control of development nor the public participation procedures which we have in this country.

A succession of draft directives - now more than twenty in number - has come from the EEC Commission but no directive yet exists. The latest draft directive lists in Annex 1, a number of developments which must be subjected to an assessment, and in Annex 2 lists developments which may be subjected to an assessment. Annex 1 consists of particularly polluting industrial projects and major civil engineering works.

The developer would have to submit with his planning application certain information, including a description of the environment likely to be affected, an assessment of significant effects on the environment, and a description of the measures envisaged in order to reduce those effects. This information would be made public with the planning application. The local authority would have to take into account public representations, and would then itself have to make an assessment of the likely significant effects of the proposed project. This assessment would have to be published along with the planning decision.

The British Government has remained steadfastly opposed to any mandatory requirement that an Environmental Impact Assessment must be prepared. Difficulties which the Government foresees are that any attempt to list developments so as to require a special procedure is to create artificial distinctions; that regulations requiring developers to supply certain information along with their planning applications will open the door to objectors to go to the Courts on the grounds that procedures have not been complied with (this is what has happened in the

United States); that the suggested procedures would add to development costs and would increase delays; and finally the Directive is seen as a means of gradually introducing the control of land-use and operations in agriculture and forestry which are free from control in the United Kingdom.

Both the Lords and the Commons considered the question of Environment Impact Assessment and the EEC draft Directive in the spring of this year, and the British Government's view carried the day. One pro-Directive view which was advanced in the House of Lords was that British opposition to the Directive was frustrating the improvement of development control in some European countries which did not have the benefit of a system such as our present one, and that the Government was therefore failing in its European responsibilities. As against this the view was put by one noble lord, in support of the Government's view, that "the fact is that new development is what we're short of, bureaucracy is what we're long on". The Government's position was summarised by its spokesman in the Commons Standing Committee who said "Our present system enables assessments to be made of environmental impact when required. We remain to be convinced that it is necessary or desirable to replace that eminently practical system with a rigid mandatory one. For these reasons the Government's policy of encouraging environmental assessment within the principles of our present law is the only sensible one to follow at present".

Which brings me very conveniently to the consideration of a very recent major planning application under our present law, and of the non-statutory impact assessments which were prepared in connection with the proposals. I refer to the application by the National Coal Board to exploit the recently-proved North East Leicestershire Coalfield, often called the Belvoir Coalfield. The Coalfield is about 90 square miles in area, mostly in rural Leicestershire but extending a little beyond the county boundary into Nottinghamshire and into Lincolnshire. The estimated coal yield over a life of about seventy years is 500 million tonnes. It is proposed to raise the coal at three mineheads – Asfordby, Hose and Saltby – all in Leicestershire, and with annual coal outputs of 2.2 million tonnes, 3.0 million tonnes, and 2.0 million tonnes respectively. The respective annual dirt outputs of the three mines would be 0.55 million tonnes, 1.50 million tonnes, and 0.67 million tonnes. Total numbers employed below and above ground would be 4,100, working on a three-shift system.

Each minehead site would have two enclosed winding towers, one for coal winding and one for men and materials. The coal winding towers vary between 170 and 191 feet in height, and the man winding towers are about 150 feet. In addition, there would be bulky coal preparation buildings and covered coal stores of about 100 feet and 85 feet in height. Large rapid-loading bunkers would transfer the coal to 'merry-go-round' trains, and there would be a variety of lesser buildings such as offices and workshops, together with extensive car parking areas.

The National Coal Board proposed that all the minestone spoil arising from the shaft sinking, from the driving of the underground roadways, and from the later actual mining of the coal would be tipped on-site adjoining each minehead. Compared with traditional mine tips, the tipping would be relatively low in height but very extensive in area; the largest tip would be about 670 acres in extent, and would be at the Hose mine. The development of each tip was proposed to be a phased programme, and would be progressively restored to agriculture. The planning application, however, indicated tipping for only 50 years of spoil output, as compared with a mine life of 70 years.

The planning application was submitted in August 1978, and in January 1979 the Secretary of State for the Environment called-in the application for his own decision. There was a preliminary public hearing for two days in May, 1979, to identify the main issues to be examined at the later public inquiry, to see whether there may be a lack of information on any matters, and to discuss procedures at the public inquiry. The inquiry itself commenced on the 30th October, 1979 with the Inspector being assisted by two Assessors; one on environmental matters and one on mining matters. It finally concluded on the 2nd May, 1980, after public sittings totalling 84 days. At the time of the preparation of this paper, early in September 1981, the decision of the Secretary of State is still awaited.

More than a year before the submission of their planning application, the National Coal Board had published a Feasibility Study, prepared by its consultants and entitled 'Belvoir Prospect'. This Study, in addition to exploring and recommending on the practicalities of mining, also examined to a limited extent the impact of the proposals. In the period between the publication of the Feasibility Study, and the submission of the planning application, discussions were held between the National Coal Board and officers of the local planning authorities to probe and examine aspects where further information was required. These discussions were continued on a more formal basis in the later period following the receipt of the planning application, and prior to the public inquiry

One very specific matter which was discussed in this later period, immediately before the public inquiry, was one which was identified by the Environmental Assessor at the preliminary public hearing in May, 1979. This was the desirability of the various major parties at the inquiry - the National Coal Board, the local authorities, and the organised objectors - trying to reach agreement on a methodology to be used in discussing the visual and landscape impact of the National Coal Board proposals in the public inquiry.

These major parties did meet several times to discuss the problem and did agree finally that any or all of a number of identified methods would be used in assessing and discussing visual and landscape impact. One agreed graphical method was by means of photomontage, from viewpoints agreed between the parties and showing the National Coal Board's proposals superimposed to scale on photographs of the present-day views. To assist in photomontage accuracy and realism, a helicopter was flown at the mine sites at winding tower height at the time the agreed viewpoint photographs were taken. Other graphical methods agreed were to develop true-to-scale sections through the mine sites and the surrounding countryside and, allied to this, to present in map form those areas of surrounding countryside from which the minehead sites would be seen when they were developed. A computer programme was used to produce readily this latter information, taking account of intervening ridges, hills and major tree groups. Finally, there were three numerical methods which, in various ways, attributed numerical 'scores' to the quality of the existing view or landscape, and then similarly scored the detraction from that landscape as a result of the proposals. These latter methods inevitably have a degree of subjectivity attaching to them.

But this is to digress a little from the mainstream of my account of the proposals, and of the Impact Assessments which were prepared. The National Coal Board Feasibility Study had recognised the impact of their proposals in two ways. First, it had looked at the existing situation with regard to a number of environmental matters, and as a result had arrived at a 'short list' of possible locations which on the whole were the least sensitive areas in environmental terms for the location of the mineheads. The matters examined in broad site-selection and site-rejection - a sieving-out process on a map basis - were:-

Ecology, and Sites of Special Scientific Interest

Agricultural Land Quality

Proximity of Settlements

Landscape Value

Archaeology and Conservation.

Having thus short-listed the broad areas which had least impact in the context of the coalfield area as a whole, the National Coal Board then sought to reconcile this selection of possible surface locations as compared with their 'ideal' surface sites when looked at solely from the underground mining aspects, where such matters as accessibility of coal seams and underground travelling time for miners are of great importance. This examination resulted in a shift away from those 'ideal' surface locations to more environmentally acceptable locations. Thereafter, the National Coal Board looked in more detail at impacts resulting from the development of these specific surface sites. The impacts they considered were:-

> Visual impact in relation to residents in the area, in relation to road users in the area, and in relation to proximity to sensitive features such as Conservation Areas.
>
> Noise in relation to residents in the area in respect of the mine construction and production stages, and including railway noise.
>
> Loss of landscape quality due to the intrusive nature of mine buildings.
>
> Loss of agricultural production as a result of the surface developments.
>
> Capacity of the existing road network.
>
> Traffic intrusion in existing settlements during the mine construction and production stages.

It was clear that there were many other aspects and impacts to be considered beyond the ones which had received attention in the National Coal Board Feasibility Study. As soon, therefore, as the planning application had been received, work commenced in the Planning Department of the Leicestershire County Council on producing three Assessments; a Need Assessment, a Mining Assessment, and an Impact Assessment.

The advertising of the planning application and publicity for the proposals in the local press and on local radio produced a large number of representations from individuals, from organised protection groups, and from Parish Councils. These representations were, of course, a valuable indication of what residents in the area perceived as being the issues, and the order of importance of those issues.

The three Assessments formed the basis of a comprehensive report which was submitted to the County Council. Like the Assessments, the report dealt not only with the National Coal Board proposals in the planning application and the consequences thereof, but also with other developments which would flow from those proposals. In particular, it dealt with the requirement for and impact of railway links, the substantial electric power installations, and the new areas of housing and other land uses which would be needed.

The County Council in March 1979 accepted the Report and agreed with its conclusions. As regards those matters most directly relating to the impact of the proposals, the Council decided that representations be made at the Public Inquiry, that the National Coal Board application be refused, one of the reasons being that "the scale of working proposed is unacceptable by reason of the resultant social, environmental, infrastructural and economic effects". The County Council further decided that if nevertheless the Secretary of State for the Environment did grant permission, the Council must be satisfied that adequate safeguards would be imposed with regard to dirt disposal, subsidence, the environment, landscaping, rail traffic, recruitment of labour, and contributions to infrastructure and other costs, and that those safeguards must be met by the imposition of conditions and by the signing of agreements between the National Coal Board and the Leicestershire County Council.

I think it is worth setting out those matters which were included in the County Council's Impact Assessment, because I believe it demonstrates that the Council did very thoroughly examine the National Coal Board's proposals and their impact over a wide field.

The impacts were examined under four main heads. The first of these was The Physical and Natural Environment, and the impacts considered were those of visual intrusion, and the effects on the landscape and the natural environment. The second head was The Established Economy in the Area, Employment and Resources. This was the largest section of the Assessment and covered agriculture, employment and the local economy, housing and other induced development, infrastructure and public sector finance. There were appendices dealing with the individual farms affected at each site, estimated losses in agricultural production, and a forecast of County Council capital and revenue expenditure arising from the proposals.

Under the heading of Health, Safety and Convenience were examined impacts arising from emissions, noise, subsidence and apprehension of danger, together with the wide-ranging transportation impacts which would arise. The fourth head was that of The Social and Cultural Character of the Area and the matters considered were impacts arising from incoming population, recreation impact, and disturbance to the historic fabric of the area.

All these matters were pursued in the Public Inquiry when expert witnesses for the County Council and other parties gave their evidence, were examined and cross-examined on that evidence, and were questioned by the Inspector and the Assessors. Quite apart from thus meeting the normal purposes of this or any other Public Inquiry, this process of identifying the wide-ranging issues and then examining them in public had very tangible results. These results were in the form of assurances by the National Coal Board, acceptance of planning conditions by the National Coal Board, or agreements between the National Coal Board and bodies such as Leicestershire County Council to be implemented in the event of planning permission being granted by the Secretary of State.

These assurances, conditions or agreements included such matters as there being no additional mine to the three proposed during the life of the coalfield; that the National Coal Board would, with the County Council establish local liaison committees to keep the public informed; that no coal would be transported by road; that the National Coal Board would make a payment of £1 million to be administered and expended largely by the County Council in the provision and maintenance of off-site tree planting to mitigate the effects of the surface developments; that the National Coal Board would make a payment of £4 million to the County Council for highway works to improve the present road network and provide traffic relief to certain villages; and agreement between the National Coal Board and Melton Borough Council in Leicestershire to deal with the control of noise and dust.

In addition to these very positive measures resulting from the identification and examination of the effects of the proposals, another result of the use of Impact Assessment has been that in the forum of the Public Inquiry matters have been examined which rarely receive such a public airing. By that I mean such subjects as noise, dust control, water quality, land drainage and so on which are the subject of other controlling legislation.

In the event of the Secretary of State being minded to grant permission, there was one fundamental matter on which the National Coal Board and the County Council could not agree. That was the question of the disposal of the vast quantities of spoil expected to arise from the mining operations. I briefly described earlier how the National Coal Board proposed to tip the spoil at each of the three minehead sites. The County Council found this unacceptable and urged the Secretary of State not to agree to this particular proposal; instead the spoil should be transported away from the coalfield for disposal. Various sites had been examined, including disposal in the Wash and in the North Sea. These and other sites, however, possessed known or anticipated hazards from the environmental point of view.

The only site where there seemed to be no significant environmental side-effects, and indeed where environmental improvement would result, was the worked-out brick clay pits in Bedfordshire. There, great areas of land lie waste, and it appears that it is only an operation on the scale of the Belvoir Coalfield producing huge quantities of spoil over a long period of time which would enable reclamation and an improvement in the environment to take place. Leicestershire County Council therefore pressed the point that the spoil should be transported by rail to Bedfordshire for disposal in the clay pits.

The environmental grounds on which the County Council objected to on-site tipping were the loss of agricultural land and production, landscape loss, visual impact, noise of tipping operations adversely affecting residents, dust nuisance, and pollution of water courses by surface water run-off. Remote disposal would, of course, be a far more costly operation than on-site disposal. The National Coal Board argued that they had extensive experience of restoring colliery tips to agriculture, and that the area out of agricultural production at any one time would not be large. They denied that there would be any loss of landscape quality due to the tipping; rather, it would be landscape change. Indeed, their expert witnesses at the Public Inquiry argued that a well-designed visually interesting tip formation could in the course of time result in landscape enhancement at the chosen locations. Finally, the National Coal Board pointed out that hauling the spoil to somewhere as far away as Bedfordshire would use substantial amounts of energy, and would result in additional railway noise for people living near the rail lines.

I hope I have been able to demonstrate that the identification and consideration of the consequences of a planning proposal is a very worthwhile and necessary operation. The wider and deeper the process of examination, the more likely will it be to result in extensive information on which a planning decision can be based. Although the rather grand title of Environmental Impact Assessment may be recent, the process is not. It has certainly been followed to varying degrees in the planning procedures in this country since the introduction of our present system of control of development in the 1947 Town and Country Planning Act. Indeed, when the House of Lords earlier this year debated the draft Directive from the EEC, they were reminded by one speaker that Environmental Impact Assessment had been around in one form or another for centuries, and he cited a case from 1602 where Elizabeth I asked the Sheriffs of Hertfordshire and Essex to investigate the impact of a proposed aqueduct.

I think, therefore, that perhaps the greatest benefit to flow from the interest and debate of the past few years on the question of EIA and on whether it should be mandatory in certain cases, has been the influence it has had on practising planners in the way in which they, themselves, approach the process. I believe it is leading to a more systematic and structured identification, examination and evaluation of the consequences of major development proposals.

In conclusion, I would sound a note of caution on two particular aspects. The first concerns the form, content and presentation of Environmental Impact Assessments. With the widening of the process of examination, there is a tendency to use more and more experts dealing in ever-narrowing fields. The result may be an assembly of a mass of facts, conjecture and opinion, presented in a form and language which is foreign to the public. Indeed, it may present difficulties to those who are intended to use the Assessment in reaching a decision. This tendency, unchecked, could lead to disenchantment with the process itself.

My second point has to do with the purpose and use of the Assessment, and it relates back to the point I have just made. The Assessment is only a tool; it should be clear and easily understood in order to be of greatest value in helping to reach a decision on a proposal. But, helpful though an Assessment may be, in the end it is the weight one decides to attach to the different benefits and disbenefits of the issues examined, and beyond that the formulation of the decision itself, which remain the most difficult parts of the whole process.

Finally, I would wish to place on record my thanks to Mr. Kenneth Baldwin, ARIBA, MRTPI, Dip.TP(Leeds), a member of my staff who has been most concerned with the environmental implications of the Vale of Belvoir application and was responsible for the research and the preparation of this paper.

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PRACTICAL ASPECTS OF THE LOW FREQUENCY NOISE PROBLEM

by

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AUTHOR'S NOTE

The facts are of course sacred, but any views or opinions expressed in this paper are those of the author and are not necessarily those of his employer.

On the question of terminology - the rather esoteric language of noise provides a barrier between the acoustician and other members of the community. Every effort has been made to lower that barrier but as some of the data used is historial, it has perforce been presented in terms of varying bandwidths (Octaves - 1/3rd Octaves - Narrow Band - etc).

Unless specified otherwise, all decibels (dB) are quoted in dB re 2×10^{-5} Pa.

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The author acknowledges permission to publish this paper granted by Rolls-Royce Limited and thanks his colleagues Mike Austin and Mike Nelson for the long hours they have spent taking and processing the low frequency noise measurements on which much of it is based.

WHY LOW FREQUENCY NOISE?

At the 1980 Annual Conference of the National Society for Clean Air presentation of a paper on Environmental Noise Criteria (Ref. 1) covered in a very expert manner the types of noise which might loosely be described as 'din' but made no reference to either low frequency (audible) or infrasonic (largely inaudible) noise. During subsequent discussion the presenter stated that the question of low frequency noise had not been avoided - but had been ignored (Ref. 2). This provoked discussion to an extent which made it desirable for the topic to be included in the Society's 1981 Conference Programme.

As a somewhat polemical aid to wider discussion, this paper describes some practical aspects of both the historial and current low frequency noise problem, proposes techniques for its specification and control, outlines some silencing methods and suggests an action plan for the National Society for Clean Air.

DEFINITIONS

The Low Frequency sound referred to in this paper is characterised by airborne waves, propagated at the characteristic speed of sound in air (344 m/sec) at 20°C and having frequencies arbitrarily chosen as below 261 Hz which is middle C in the International concert pitch scale.

The term Infrasonic refers to frequencies below the generally accepted lower limit of auditory perception of 20 Hz, although it is known that infrasound, while losing its tonal quality at frequencies below 16 Hz is in fact audible, given a sufficient intensity, down to 1 Hz.

LOW FREQUENCY SOUND

Low Frequency sound is omnipresent and although our ears do not readily detect it, the noise spectrum measured in even the quietest location is dominated by energy at the low end of the spectrum (Fig. 1). However, very often, and certainly much more frequently than is currently recognised, the levels of low frequency noise are enough to interfere with our daily lives to a degree sufficient to cause significant misery, distress and economic penalty to certain people and organisations.

PROPAGATION OF LOW FREQUENCY SOUND

As any sound wave travels through the atmosphere its intensity falls according to the familiar Inverse Square Law so that the sound pressure decays by 6 dB with every doubling of distance from source. But high frequency sound is also subject to an "excess attenuation" caused by scattering and molecular absorption and the fall-off is much greater than for low frequencies which can travel over great distances. Furthermore because of its long wavelength*, low frequency sound radiates in a spherical manner, rather like the ripples caused by a stone being dropped into a pond, and can cover a vast area. Some well documented examples of this include the diary of Samuel Pepys, who on 3rd June, 1665, noted that people in London heard the gunfire from English and Dutch men o'war engaged in battle in the North Sea (Ref. 3), and in 1883 the spectacular volcanic eruption of Krakatoa from which infrasonic waves travelled five times around the world. More recently, and with the benefit of electronic recording, infrasonic waves from the devastating explosion at the Nypro Chemical Works at Flixborough, North Lincolnshire, were clearly detected at Newbury, Berkshire, and Eskdalemuir, Dumfriesshire, (Ref. 4). In terms of more local phenomena, low frequency noise from industrial plant, or booms from supersonic aircraft can cause puzzling disturbance or annoyance at distances so remote that the real noise source is by no means apparent.

WHAT WE DO NOT KNOW

In addition to good historical data on low frequency noise propagation, cases of disturbance or even physical distress are similarly documented. For instance, Arthur Greenwood's famous novel, "Love on the Dole", published in 1933, refers to the fact that, "The thump of the presses makes the workers feel sick".
(Ref. 5).

Somewhat surprisingly therefore, it was not until 1973 that the first international colloquium on Infrasound was held in Paris and we then had to wait until 1980 for the first international conference on Low Frequency Noise (Ref. 6). Regrettably, even today there is widespread ignorance as to its quantitative and subjective effects, no convenient measurement unit to describe it, and no definitive guidelines as to the extent to which it should be controlled.

THE PROBLEM

Apart from the matter of acoustic fatigue in buildings

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* Sound Wavelength $= \dfrac{\text{Speed of Sound}}{\text{Sound Frequency (Hz)}}$

and other structures, the main problem arising from excessive low frequency noise concerns people who can be disturbed, annoyed, made wretched or ill by acoustic insult to a degree which can be disruptive on a local scale and which nationally produces significant economic and social penalties.

However, just as with other forms of noise, the population at large exhibit markedly differing levels of individual sensitivity to low frequencies. Effects noted by the author in a variety of situations in several countries are:-

At the levels of low frequency noise generally encountered in everyday life, there is no observed damage to hearing.

With random (as opposed to pure tone) noise many of those exposed are not sure whether they hear it or feel it - and they refer to "the vibration". In a given population exposed to a sufficient level of low frequency noise some people can be distressed to an extreme degree while others remain quite unaffected.

Once a complaint-inducing level has been reached, there is no correlation between absolute sound pressure level and the number of complaints from a given population - people either complain or they do not.

Female (employees) tend to demonstrate earlier sensitivity than male (employees) but the author has insufficient data to make the same deduction regarding the population at large.

Once a person has displayed some sensitivity to low frequency noise, further exposure lowers the sensitivity threshold.

Any sensitivity is exacerbated by the presence of other stresses.

The low frequency sensitivity syndrome includes:-

Feelings of irritation/unease/stress/undue fatigue

Headache
Nausea
Vomiting
Heart Palpitations
Disorientation
Swooning/Prostration

There is some controversy as to whether or not some or all of these symptoms are psychosomatic, but in practical terms the argument is somewhat academic as if people have, for whatever reason, stopped work because they feel ill, the result is lost production and the tying-up of scarce and valuable specialist effort. There is of course no sympathy for double-blind trials when production is at a standstill.

WHAT CAN WE HEAR?

In terms of practical application and problem-solving, it is important to recognise what human beings can hear, what they react to, and what damages them.

It has long been recognised that audibility or loudness sensation can be measured down to 1 Hz (Ref. 7) and the author's experience of gas turbine installation once suggested that infrasound at about 3-5 Hz was indeed a factor to be considered, either because it appeared to be a problem in its own right or to act as an annoying modulator of low frequency sound.

This led to considerable effort being expended in trying to directly eliminate these infrasonic disturbances, but in spite of considerable success in reducing their absolute level the subjective effect was always disappointing.

Fortunately a conversation with Professor Geoffrey Leventhall of Chelsea College, London, revealed that he considered that it should prove more effective if low frequency noise were suppressed. He further suggested that the acoustic spectrum around 40-60 Hz should be attacked. Now if this suggestion were valid the engineering problems would be greatly eased because it made a simple acoustic absorptive silencer seem feasible. For an acoustic absorber to be most effective it should be 1/4 wavelength thick, but at 5Hz the sound wavelength is 225 ft giving a 1/4 wavelength of 56 ft which was wildly impracticable. However, at 60 Hz the 1/4 wavelength is only 5 ft which gave reasonable hope of achieving some attenuation with a manageable sized absorber. Such an acoustic splitter was installed and the results are shown in Fig. 2. Great lessons in practical silencing were learnt from this installation because the attenuation achieved over a quite narrow band of low frequencies eliminated complaints about what had hitherto been regarded by the local community as a noisy installation.

This result thus emphasised the importance of low frequency sound relative to infrasound and suggested that before undertaking the design of expensive silencers, due regard should be paid to the absolute levels of existing sound relative to what it is known we can hear.

Although some later work has been done, the hearing threshold data which has been successfully used in practical applications by the author is given in Fig. 3 (Ref. 8). Doubtless the conference will be updated in the matter by a researcher from Chelsea College (Ref. 9).

MASKING

As reference to Fig. 3 shows the marked increase in hearing sensitivity with increasing sound frequency, it is not unreasonable to expect that a higher frequency noise of even moderate level may effectively mask either low frequency or infrasonic noise. Practical experience shows that this is indeed so. In one case young women who had demonstrated (arguably undue) sensitivity to low frequencies from gas turbines worked apparently happily when pop music from a transistor radio actually raised their absolute noise exposure level, while masking the low frequencies. Permanent installation of a piped music source was however ruled out on the grounds that although it might please the girls, there were more cost-effective ways of satisfying the local community.

More mundanely a test bed installation situated amid high quality housing on the edge of the Cotswolds, and which gave rise to fairly frequent noise complaints has apparently ceased to exist in acoustical terms since the opening of the nearby M.5 motorway which cuts a vast swathe of higher frequency noise throughout the countryside. An illustration of motorway din is given by the fact that at the author's home one mile south of the M.4 under the right conditions of temperature inversion or wind direction, the night time ambient level can increase from 30 dBA to about 50 dBA. Under the same conditions and assuming only inverse square law attenuation, the 30 dBA contour would lie eight miles from the motorway!

UNMASKING - OR CAN SILENCING MAKE IT SEEM WORSE?

There are few greater sources of din than a high speed jet discharging from a gas turbine engine and vast sums of money are spent on silencing the test beds on which their performance is checked. Now a large jet running in the free-field spreads from the exhaust nozzle at an included angle of 15°. Therefore if the initial jet velocity is sufficiently high (say 3500 ft/sec) the jet is still travelling quite fast when it has spread to a large diameter and is thus able to generate significant low frequency noise. But this low frequency is generally masked by the broad band 'roar' (Fig. 4) and complaints of low frequency noise from such jets are rare.

Fig. 4 shows noise measurements, taken at the same position relative to the final exhaust nozzle, of a jet engine under both free-field and test-bed conditions. The difference between the two curves is thus the insertion-loss or silencing effect of the test bed. Note however that the high frequency (jet roar) noise is reduced much more than the low frequencies around 31.5 Hz. So although this low frequency noise is reduced in absolute terms the 'silenced' spectrum is dominated by it, and subjectively the result can be distressing to some people.

SOME PRACTICAL EXAMPLES OF LOW FREQUENCY NOISE PROBLEMS

A variety of practical problems from the author's casebook is described below:

SILENCING OF A GAS TURBINE TEST BED

Quite recently a test bed was designed, built and commissioned for testing large aero engines of the high by-pass-ratio type which develop high levels of thrust while discharging their exhaust jet at low velocity and are thus inherently quieter (approximately 15 dB) than pure jet engines giving comparable thrust.

As soon as engine testing commenced in earnest, severe problems arose in that employees in nearby offices were firstly annoyed and then started to demonstrate the classical low frequency sensitivity syndrome. At the same time, cracks appeared in adjacent buildings. An urgent solution was required, and as usual one of the major requirements was that any silencing modifications should not induce performance losses in the exhaust system.

Fortunately model tests already carried out at 1/30th scale had indicated that the fitting of a fluted nozzle (as fitted to early jet aircraft such as the Comet) at the entry to the test bed exhaust duct should give the desired attenuation. A full scale mixer nozzle was made and fitted and demonstrated an overall noise attenuation of 16 dB which was sufficient to prevent further structural damage. More significantly reductions of the same order in the troublesome low frequency noise spectrum (Fig. 5) around 20 to 40 Hz produced great subjective improvement and office workers who had previously been made ill when the engine was running no longer knew whether a run was taking place.

It is now intended that this type of silencer be further developed for use in the testing of high performance reheated jet engines, for although there are standard techniques for reducing jet engine noise at source, all give greater gasflow performance losses than does this fluted nozzle.

PUBLIC EXPOSURE TO NOISE FROM GAS TURBINE INSTALLATIONS

There are some situations where the general public may be exposed to low frequency and infrasonic noise from silenced gas turbine installations. These occur in the vicinity of certain power stations, whose prime movers are gas turbine engines or in the very rural environment near the pumping stations of the natural gas supply transmission system, which for obvious reasons, are sited away from large centres of population. There are of course a small number of places where housing is in close proximity to aero engine test beds, which in certain cases demonstrates an apparent lack of communication between environmental specialists and planners employed by local authorities. One aero engine test installation was deliberately sited two miles out of town to avoid nuisance and over the last two decades housing estates have inexorably spread to engulf the test area.

In terms of general layout and consequent noise spectrum, all those types of installation are quite similar, Fig. 6.

They give rise to noise complaints for two reasons:

1) The primary noise, (low frequency or infrasonic) radiated from source and entering houses either through their structure, which affords little attenuation, or through open windows.

2) Secondary noise, such as rattling windows, doors and handles on drawers. This secondary noise either causes disturbance in its own right or quite often wakes people up and they then become conscious of the low frequency pulsation.

In either case, social and political problems can arise if either the gas turbine plant noise specification is say, framed in dBA - which is irrelevant so far as low frequencies are concerned - or framed in octave band levels which only go down to 63 Hz. Social problems occur because lack of defined low frequency criteria almost invariably result in too much of this type of noise and vigorous community reaction leads to the political arguments about who pays for any additional silencing work. Again, it is almost inevitable that large sums of money are involved.

In the author's experience genuine noise complaints rarely occur when the sound pressure level in the octave band centred on 31.5 Hz is 75 dB or less outside the nearest house*. Conversely when the level reaches 85 dB complaints almost invariably occur, but between 75 and 85 dB complaints are sporadic, random and unpredictable. It therefore follows that a useful empirical guideline to avoid most problems is to limit the octave band sound pressure level at 31.5 Hz below 75 dB whatever the noise source. To illustrate this point some typical noise spectra which almost invariably caused complaint are compared with marginally 'acceptable' spectra in Fig. 7.

Interestingly enough the subjective impression from the noise emitted by these gas turbine installations is of a very low frequency thumping, with a randomly varying repetition rate of 5 Hz or less. However, this appears to be a trap for any unwary acoustician because as mentioned earlier most of the annoyance seems to be caused by frequencies around 40 Hz. Needless to say the gas turbine and power generation industries are devoting a great deal of effort into improved silencing techniques, and the public can expect a quieter future.

TELEX ROOM

A number of ladies worked all day in a fairly spartan telex transmission and receiving room where the clatter of machines, ringing of telephones, constant interruptions and queries, plus the urgency and importance of the work, produced a quite stressful environment.

When some new plant was commissioned, it raised the sound pressure level in the telex room by 14 dB at frequencies around 17 Hz.

The effects were quite dramatic in that the occupants of the room immediately displayed symptoms including headache, loss of concentration, sickness and vomiting, heart palpitations, extreme fatigue at the end of the day, unsteadiness to a degree sufficient to make them lose confidence in crossing a road with motor traffic and finally attacks of a syncopal nature.

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* One exception is quoted later - see Domestic Boilers

Urgent engineering action was taken to reduce the low frequency and infrasonic noise by about 14 dB within one week, but by then the telex operators had apparently become sensitised to a remarkable degree and so the symptoms persisted.

The problem was eventually solved by moving the telex installation to a new location, made quieter in terms of external noise by much improved masonry and glazing, and internally made quieter and more aesthetically pleasing by the extensive use of acoustic absorbent tiles and carpeting. The 'before' and 'after' noise spectra are shown in Fig. 8.

Happily the cure appears permanent and there has been no further incident during the last eight years.

VENTILATING FAN NOISE

One very common source of low frequency noise is concerned with ventilation and air conditioning systems in large buildings. In such cases the air mover is a large fan, often feeding into a plenum-chamber from which supply ducts run off to various parts of the building. Typical of the problems encountered was the case of a new computer installation, housed in a prestige block with full air conditioning, double glazing, a great deal of added acoustic absorption and hence a generally hushed ambience. However, when the people moved in and the air conditioning was switched on the result was chaos.

High levels of low frequency noise affected certain vital rooms in the building and within the first day complaints and cases of sickness were reported. Noise measurements in these rooms showed a spectrum with most of the sound energy distributed between 2 Hz and 50 Hz, and dominated by a tone at 20 Hz (Fig. 9). This was somewhat surprising since in fan noise spectra, the dominant tone tends to occur at the blade passing frequency (Number of fan blades X Rotor revolutions per second) which in this case would have given a tone frequency of over 200 Hz. It was quickly discovered that the dominant 20 Hz tone coincided with the fan rotor fundamental frequency (1 X Rotor revolutions per second) and was almost certainly due to an aerodynamic imbalance. It was then that the real arguments started, because the fan manufacturer considered that the fan was moving the specified amount of air while consuming the specified electrical power. The acoustical contractor who had supplied the air-duct silencers did not want to know, because he had been given a noise specification based on one of the internationally recognised NR curves (NR 35) which specified sound pressure levels in octave bands only down to a centre frequency of 63 Hz. As this specification had been met, the low frequency noise was irrelevant to him, although by now the building was unusable.

Meanwhile with some millions of pounds worth of computer standing idle the managers wanted an instant solution.

Results from some one hundred noise measurements showed that most of the low frequency energy was being radiated through the sides of the sheet metal air distribution ducts rather than through the air distribution nozzles in each room. So although it was recognised as not the ideal solution, the acousticians were prevailed upon to silence the offending ducts rather than deal with the noise at source. Thus by a simple application of the mass law plus the judicious use of acoustic absorption, adequate silencing was achieved (Fig. 9). Within one week, computer work restarted, and the building has now been in use without noise complaints for 6 years. The silencing treatment which was employed is shown in Fig. 10.

Incidentally, while the problem was at its height, measurements in one of the rooms where no ill effects to people were observed showed a 1/3rd octave sound pressure level of 74 dB at 20 Hz and this, together with previous experience of the community accepting 75 dB in the 31.5 Hz octave band, suggested, with obvious success, a target level of 75 dB for the low frequency sound.

The total irrelevance of the dBA scale in low frequency work is shown by the following comparison of dBA and overall sound pressure levels dB(Lin) measured in the disc cleaning room:

	dB(A)	dB(Lin)	Effect
Before Treatment	54	98	People ill
After Treatment	48	85	People unaffected

RECIPROCATING TYPE AIR COMPRESSORS

Reciprocating type air compressors are extensively used throughout industry and are a source of much annoyance. Moreover when they are used to maintain pressure in a pneumatic system with variable demand, such as a compressed air supply for a whole factory they continuously go on and off load. As the resultant noise level varies intermittently it is more annoying for a given level than a steady noise.

Figure 16 shows the low frequency spectrum measured at the air inlet to a compressor which is typical of the breed. This particular noise proved stressful to people in nearby offices, but it also affected an adjacent surgery and worse still the very low frequencies were audible inside an audiometry booth which was itself situated in a masonry structure designed to be virtually bomb-proof during the 1939-45 war.

It should be noted that the spectrum shown in Fig. 11 does not represent a continuous noise, but shows the sound pressure distribution during each repetitive 'chug' of the compressor which occurred about 6 times per second.

Standard methods of silencing would be to mount the compressor on anti vibration pads, to put an acoustically absorbent duct section in front of the air intake and to put flexible sections in all pipes connected to the unit.

DOMESTIC BOILERS

Domestic and industrial boilers, whether fired by oil or gas can give rise to disturbing levels of low frequency noise, although complaints quite often refer to 'vibration problems'.

On one occasion an Environmental Health Officer of Bristol Corporation contacted the author because a householder had complained that noise from gas turbine test beds was bouncing off cloud, with which the city of Bristol is afflicted, and drenching a certain road with low frequency noise. In such cases it is useless to simply assert that the complainant is wrong, because he is then likely to feel that he has been fobbed off by a large organisation. It is infinitely preferable to pinpoint the source and get the complainant to agree, as was done in this case. Fig. 12 shows octave band noise spectra measured in the complainant's garden and adjacent to the balanced flue of a small gas fired boiler in a nearby house, which the complainant readily agreed was the offending noise source.

Incidentally, the obvious limitation of trying to define either low frequency noise level or noise nuisance in terms of dBA units is again demonstrated in Fig. 12, for a level of 46 dBA measured at the complainant's house with the source 'ON' is reasonable by any accepted standards.

INDUSTRIAL BOILER PLANT

When hydrocarbon fuels are burnt a low frequency noise, known as combustion roar is generated. It emanates from a region undergoing turbulent combustion and is caused by temporal fluctuations in the heat release of the reacting region. The process is roughly equivalent to having a series of soap bubbles, each filled with a combustible gas which in the process of being heated and ignited expand and burst, releasing pressure waves of random frequency and amplitude which we detect as sound.

Because in industrial plant the energy release is much greater than in the case of domestic boilers, and the scale of the process is of course larger, much more of the troublesome low frequency noise is generated. This can give rise to problems in adjacent offices and workshops as well as in the surrounding community.

A typical sound pressure spectrum measured at the control desk in a boiler hall is shown in Fig. 13. It is not surprising that boilermen who are exposed for long periods complain of tiredness and irritability at the end of the working shift.

So far as the local community are concerned they are likely to be afflicted with a disturbingly intermittent low frequency rumble. In urban areas the problem is less marked than in quiet rural locations where for instance the combustion roar from oil fired heating boilers in horticultural nurseries can prove intrusive over a wide area.

There appears to be little that can be done to ensure inherently quiet combustion, but fortunately there is scope for putting acoustically absorbent sections in the exhaust duct to attenuate the low frequency noise.

This is helpful so far as the surrounding community is concerned but of course does nothing for the boilerman. It is now common practice to erect some sort of quiet refuge either in or adjacent to the boiler house so that the operator is not needlessly exposed to noise over long periods.

Some industrial boilers have a fan-assisted air supply which is another frequent source of complaint. However, silencing of fan ducts is a fairly simple procedure, and standard bolt-on silencers are readily available.

DIESEL POWERED TRANSPORT

The diesel engine, with its low firing rate and often immense power, is a prolific source of disturbing low frequency noise and the literature abounds with reference to ill effects noted in, for instance, submarine crews and locomotive drivers.

Powerful diesels used for ship propulsion produce both noise and vibration which travelling as airborne and structure-borne waves, cause annoyance and physiological reactions in passengers and crew. Results from an investigation carried out on the cabin deck of a cross channel car ferry (Ref 10) (Fig. 14) demonstrate peaks of noise and vibration in the infrasonic and low frequency bands.

In the case of diesel powered locomotives and lorries high level exposure to low frequency noise is generally confined to the occupants of the driving compartment.

DYNAMIC NOISE SUPPRESSION FOR DIESEL ENGINES

Apart from conventional silencing techniques the facilities afforded by the microchip have resurrected interest in dynamic silencing. It is possible to detect a sound wave by a microphone, reverse its phase by 180° and feed it back at the same level as the source, thus completely cancelling the noise.

In the case of ducts carrying discrete sound pulses, as for instance diesel exhausts, the silencing effect can be quite spectacular, but in the free field it is by no means as simple. However, some interesting development work is being carried out at, amongst other places, Essex University. (Ref. 11).

LOW FREQUENCY NOISE AND WINDTHROB IN CARS

The very common phenomenon of car sickness could in certain cases be related to low frequency noise. Because of the relative insensitivity of our ears to low frequency and infrasonic noise most people do not realise the levels to which they are exposed during a car journey. Furthermore, opening a window at speed induces a windthrob effect in which the car body acts as a classicial Helmoltz resonator, as does an empty bottle when air is blown across its open neck. In the case of the car however, instead of a musical tone a broad band, low frequency throb is produced.

A detailed examination of the phenomena is given by Aspinwall (Ref. 12) but a simple example of the effect of opening the drivers window of the author's car when travelling at 60 miles per hour on a motorway is shown in Fig. 15.

The researchers may be able to explain the significance of this effect - which some believe to be quite sinister - but one thing that is readily demonstrated at a practical level is the surprising feeling of freshness after say, a three hour drive on a motorway while wearing resilient plastic or glass down ear inserts compared to the feeling after a similar drive with unprotected ears.

It is also gratifying to note the disappearance from our telephone screens of a Government advertisement telling people to 'open the windows' when tired on the motorway.

BUILDINGS IN THE WIND

When a solid body such as a telephone cable is exposed to the wind it produces a distinctive humming sound. This sound is caused by the body vibrating at the frequency with which it sheds vortices, and this frequency can be predicted from the simple Strouhal Number equation

$$\frac{\text{Sound Frequency X Body Diameter}}{\text{Wind Velocity}} = 0.18 - \text{a constant}$$

Now as with telephone wires, so it is with high rise buildings, only in this case the frequency of vortex shedding is low (usually infrasonic).

There can be no doubt that humans are susceptible to fluctuations in atmospheric pressure even at very low frequencies, and any infant school teacher will confirm that young children, particularly in the mass, are unmanageable on a windy day. It follows therefore that infrasonic and low frequency noise due to high winds round buildings can cause problems.

As an example, data has been published which shows that at the top of a 16 storey hospital in Denmark people exhibited the low frequency sickness syndrome during high winds when the infrasonic noise increased by about 10 dB above the ambient level. (Ref. 13).

Is it possible that some of the depression symptoms exhibited by dwellers in high rise buildings are noise induced?

DISTANT GUNS

An irritant to sensitive people in the Bristol area is the dull thud of gunfire from Army activities on Salisbury Plain. The phenomenon, apparent on hot and humid days, causes irritation and comment and is just one more stress factor.

So the diary entry made by Samuel Pepys in 1665 is probably being reflected by less notable diarists in 1981, but whether the army activities are ever cited as a cause of domestic strife must remain a matter for conjecture!

AN APPLICATION OF LOW TECHNOLOGY

The author was telephoned by a colleague at Bristol University whose office overlooked the outlet from a large ventilation fan. This fan produced a tone of approximately 150 Hz which annoyed him but his repeated complaints had always met with the response that silencing of such a low frequency sound would be very expensive and money was not available. Annoyance caused by the tone had by now built up to an apparently intolerable level and the victim was beginning to feel ill. He therefore asked for an instant, cheap solution, but was unsympathetic to the suggestion that he vacate his office. In a flash of some sort of inspiration the author realised that such a tone, occurring inside a room where there would be neglible acoustic absorption at 150 Hz would set up a standing wave pattern. The complainant was given some technical advice to move his desk and chair by 2 feet, plus an arbitrary suggestion that the move should be to his right. The technical advice gave him a quarter wavelength shift across the standing wave pattern and the quite arbitrary guess fortunately moved him from a noise peak to a cancellation trough.

The erstwhile victim was more than delighted with the instant solution to his problem and gave it more than adequate publicity on which the author has dined out ever since!

THE BRISTOL HUM

In the field of low frequency noise control an exercise not unconnected with the National Society for Clean Air, and which attracted world-wide publicity, has recently been completed.

Complaints of low frequency noise are endemic and certainly in the gas turbine industry are handled as a matter of routine. However for some time certain residents of the City of Bristol had complained of a persistent and widespread problem. Eventually the local authority decided to mount a major campaign to trace the source of what rapidly became known as the Bristol Hum.

Because of the very close relationships engendered by joint membership of the National Society for Clean Air, the Environmental Health Department co-opted Rolls Royce Limited into the exercise. The company was delighted to be able to co-operate and in any case as any significant noise within ten miles radius of the works is often attributed to the aero engine industry, were glad to be able to identify what the problem was, if indeed it existed at all.

As might have been expected, and in spite of widespread rumour and speculation, the joint exercise established that there was no omnipresent hum throughout the city, but that in common with any other urban environment there were a multiplicity of noise sources, some of which persisted at night when the general ambient levels had fallen by about 8 dB from their daytime level. Therefore these noises could in certain cases become quite intrusive. So, on the Eastern side of the city the hum was in fact the motorway, near the city centre it was industrial plant, and on the western side it was tonal in character, of fairly low level, quite annoying to sensitive ears and emanated from a bank of large fans in an industrial complex. Having unambiguously located this particular noise source the local authority are taking steps to have it silenced, but this will do nothing for those in other areas of Bristol, Dorset, Norfolk - The United States - Australia or New Zealand who wrote to wish us well as they were themselves afflicted!

The genuine 'Bristol Hum' with its characteristic tonal quality consisting of true Low Frequency noise is shown in Fig. 16 where it is compared with an ambient spectrum measured at the same location. It should be noted that the ambient spectrum is itself dominated by infrasonic energy although the subjective effect was one of absolute quite! One should therefore never be mesmerised by the numbers-game, but should remember that ears are an indispensable tool in assessing the subjective effect of any noise.

Lessons which everyone can learn from the Bristol Hum investigation are that quite low level noise can cause a great deal of misery to sensitive people and that co-operation engendered by bodies such as the National Society for Clean Air can achieve immense benefit to the community at large.

PRACTICAL DIFFICULTIES OF LOW FREQUENCY NOISE SUPPRESSION

Although some specific silencing techniques have been described above, there are some very important aspects of the general case which should be noted.

The physical principles of noise reduction apply equally at all frequencies but in the case of low frequencies the engineering task is made much more difficult than it is for high frequencies. Effective silencing of any source can only be achieved in three ways which are:-

- Reduction in generated acoustic power
- Suppression of the noise after generation
- Prevention of any residual noise from getting to an unwilling receiver.

In practice of course, successful silencing depends on a combination of these.

The special difficulties in low frequency silencing arise from the fact that:-

- Many of the source processes are inherently noisy (viz. combustion, turbulent gas flow, etc) and those sources which effectively generate great amount of acoustic power at low frequency are themselves comparatively huge. So the scale of the engineering is often large and expensive.

- Suppression of noise depends usually on a combination of transmission loss, enclosures, etc. and acoustic absorption to mop-up any reverberant noise in either the source or receiving enclosures, or in any ducts along which the noise must travel. But because of the quarter-wavelength law for efficient absorption plus the fact that low frequency sound has very long wavelengths, often matching the dimension of the buildings around, effective absorbers are usually impractical. Adequate transmission loss by enclosure is also difficult to achieve. For example, whatever the transmission loss of a structure at a medium frequency, say 1,000 Hz, it is likely to be 25 dB less at a typical low frequency of say 32 Hz.

To reduce the propagation of residual noise from source to receiver depends usually on a combination of distance and shielding. But as has already been shown, low frequencies travel well over great distances, the long wavelength makes them spread spherically and they easily refract over most practical barriers if indeed they do not simply pass through them.

These difficulties, plus the fact that there are no accepted criteria for low frequency noise has meant that throughout industry, just as at the 1980 Annual Conference, the problem had been ignored.

A NEW MEASUREMENT UNIT

There exist well established techniques for measuring low frequency noise but for control to be applied in a scientific and cost-effective manner low frequency and infrasound must be described in simple units and it is imperative that some standardisation is established. For an acoustician, the noise can be adequately described by enumerating the sound pressure levels in given frequency bands, as indeed has been done throughout this paper. But if these data are to be used in a wider context of defining permissible limits and describing a noise simply, they must be turned into one simple number such as is given by the A weighting curve when defining higher frequency noise.

As has been shown, the A weighting curve is by definition unsuitable for describing low frequencies or infrasonics because it is designed specifically to exclude them. Therefore a curve which approximates to the hearing threshold (designated as the P weighting) and which falls off by 12 dB per octave towards the low frequencies (Fig. 17) is being studied by the International Standards Organisation (Ref. 14). But it has been assumed that international labour protection agencies would not favour this curve as it tolerates very high sound pressures between 2 Hz and 4 Hz.

It is therefore also proposed to introduce another curve (designated 'N') which falls off at 6 dB per octave. Fig. 17.

Once these curves and their tolerances have been defined by the International Standards Organisation each country will be free to prescribe its own limits for both low frequency and infrasound.

Definition of these parameters and the consequent introduction of meters capable of measuring them directly will considerably ease the lot of many Environmental Health Officers.

LIMITING LEVELS AND WHAT DAMAGES US

It is not clear to the author what level of low frequency noise is physically damaging to people, and only in a few extreme cases has a relationship between damage and exposure to infrasound been established on a firm scientific basis (Ref. 14).

Sweden and Norway have however established limits for the maximum permissible levels of infrasound and the current situation is as follows:

Country:	Frequency:	Level:	Time:
Sweden	2 Hz - 20 Hz	110 dB	8 hour working day
Norway	Regulation has been postponed due to increasing criticism - Possibly awaiting action by International Standards Organisation (ISO)		

United Kingdom limits are not yet defined and the National Society for Clean Air should watch developments.

AN EMPIRICAL CRITERION TO AVOID NUISANCE

In order to minimise reaction from the local community while not going to an unreasonable extent on the law of diminishing returns which characterises all silencing work, the author has found that the empirically derived criterion, shown in Fig. 18, is useful. For convenience, the data are presented in both graphical and tabular form.

CONCLUSIONS AND ACTION PLAN

Low frequency noise and infrasound currently pose a significant, but not paramount, pollution problem in industrialised society. Their ill-effects are becoming more widely known and increasing public awareness will generate social pressure for adequate control of any hazard. This will inevitably lead to legislation and both before and after that legislation is framed the author suggests that the National Society for Clean Air should:

Encourage greater awareness by ensuring that proven facts on the subject are promulgated to those having a need to know.

Make its own views known in a clear and authorative manner.

And finally, trading on its inherently ubiquitous nature the National Society should draw together the relevant local authorities, industries, professions and agencies to act as a truly multidisciplinary team to free us, so far as is reasonably practicable, from the curious rumblings of low frequency noise.

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FIG. 1

TYPICAL AMBIENT NOISE LEVELS

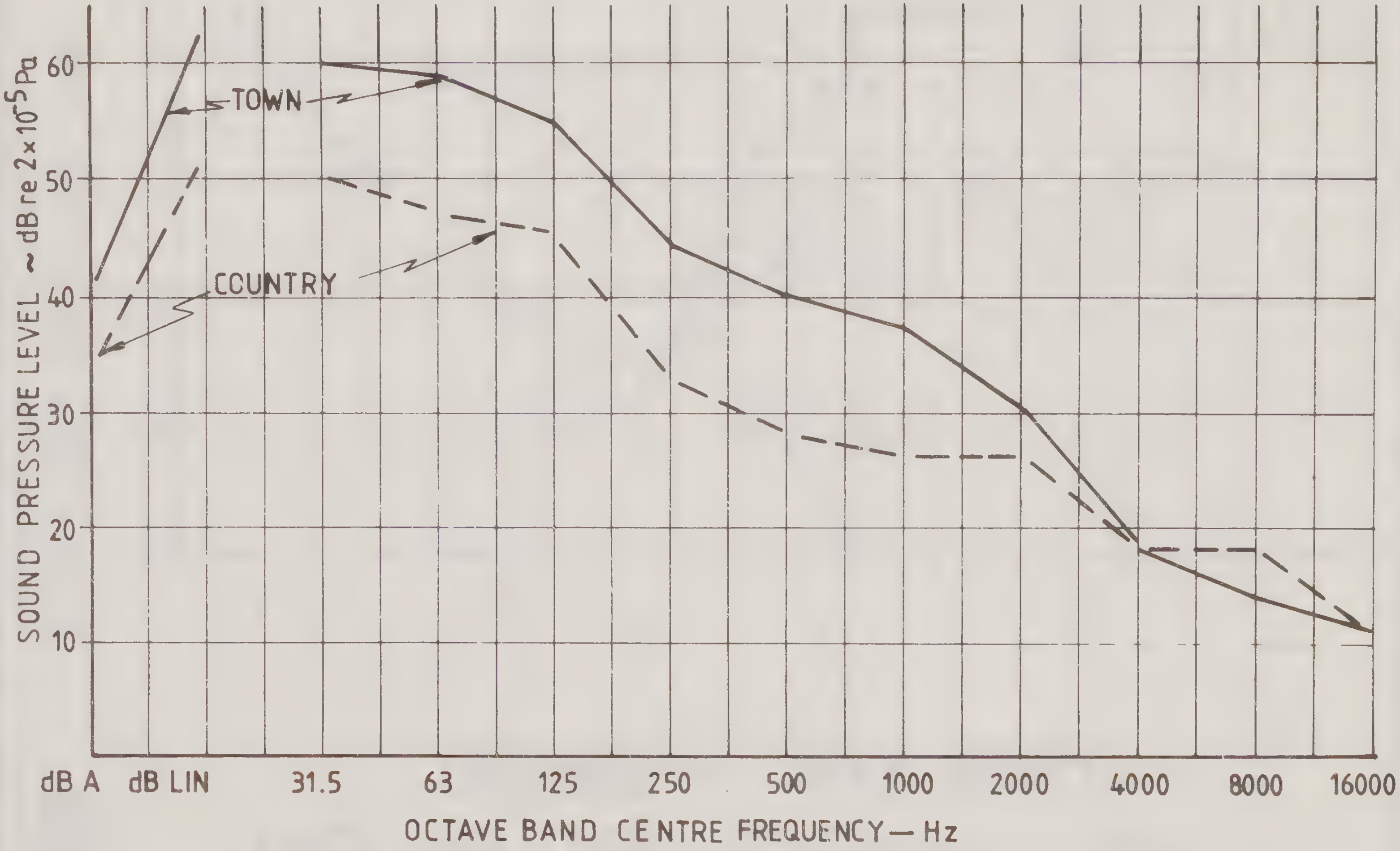


FIG. 2.

THICK SPLITTER TEST 60 YDS FROM DETUNER — MAX REHEAT

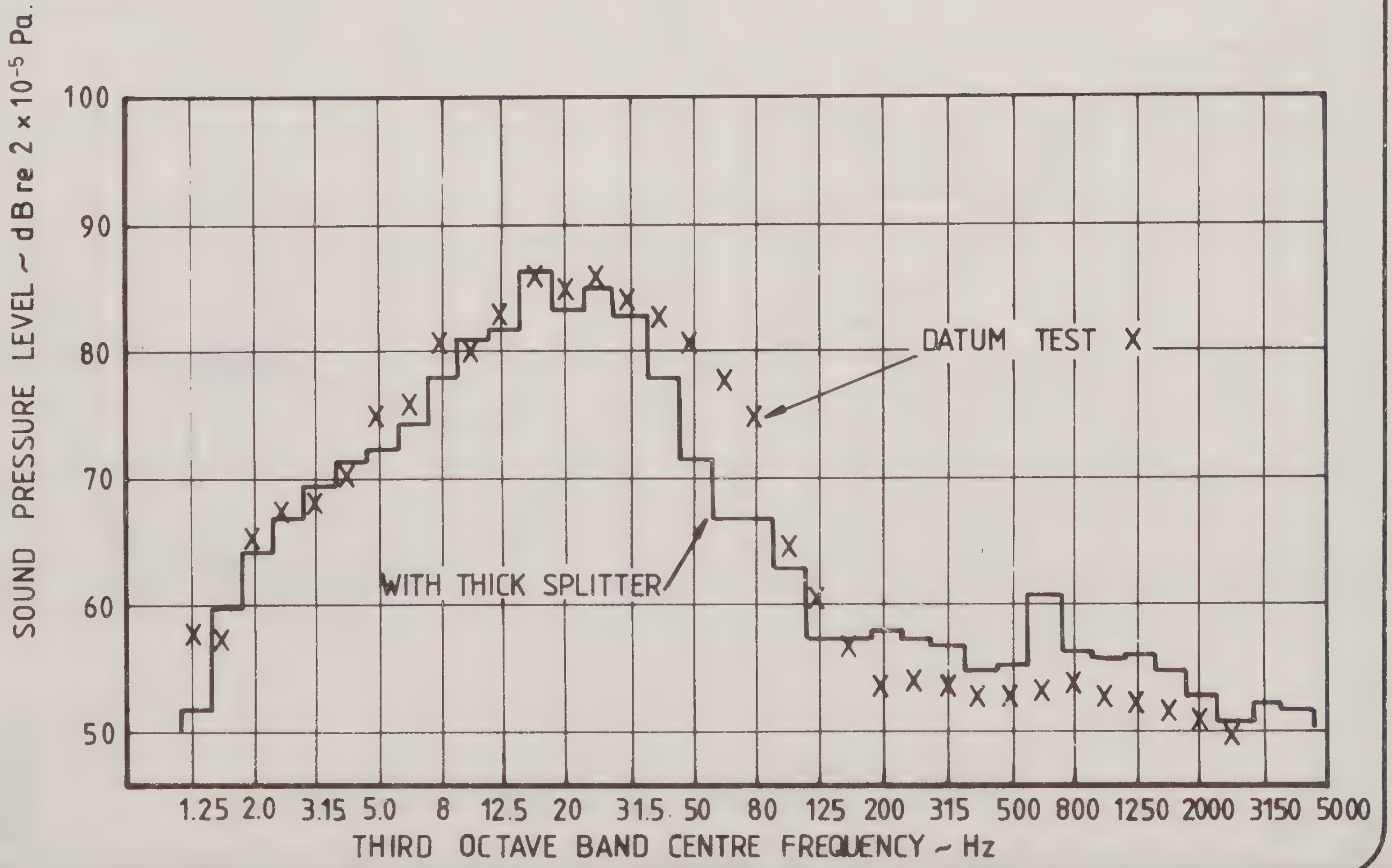
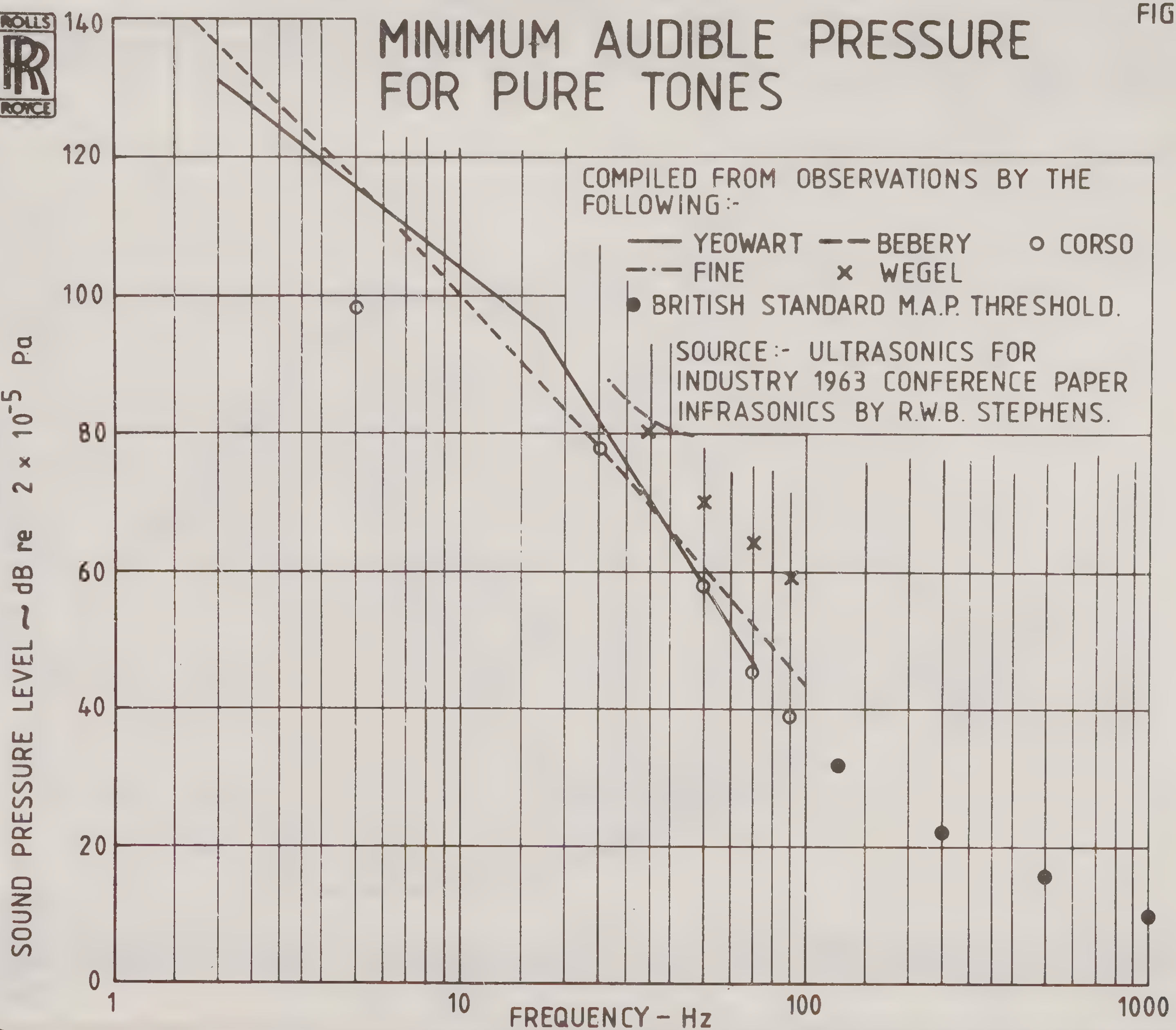


FIG. 3

MINIMUM AUDIBLE PRESSURE FOR PURE TONES



SOURCE:- ULTRASONICS FOR INDUSTRY 1963 CONFERENCE PAPER INFRASONICS BY R.W.B. STEPHENS.

FIG.4

COMPARISON OF FREE FIELD v TEST BED ENGINE NOISE

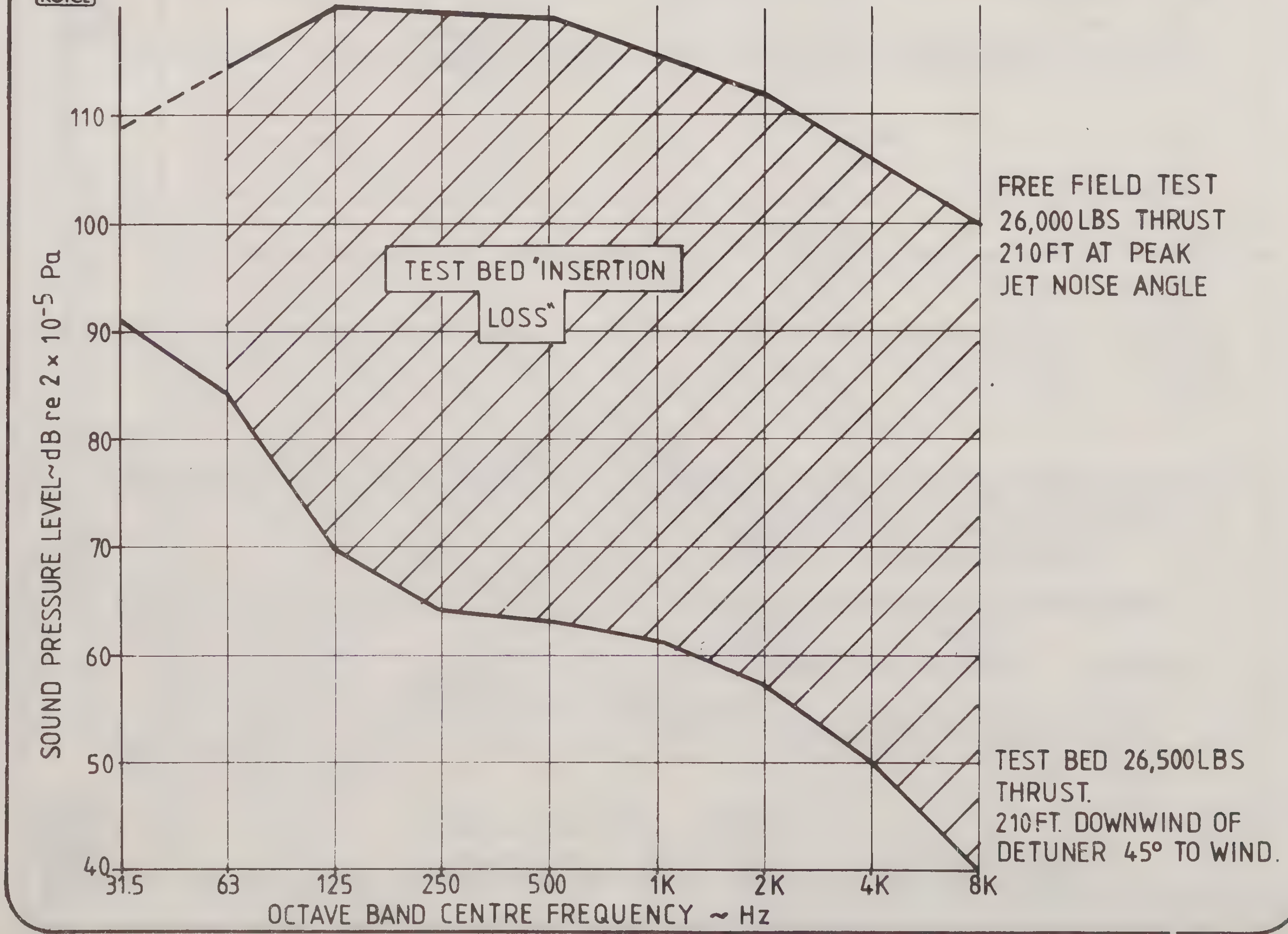


FIG.5

EFFECT OF DETUNER MIXER ON L.F. NOISE LEVELS INSIDE OFFICE

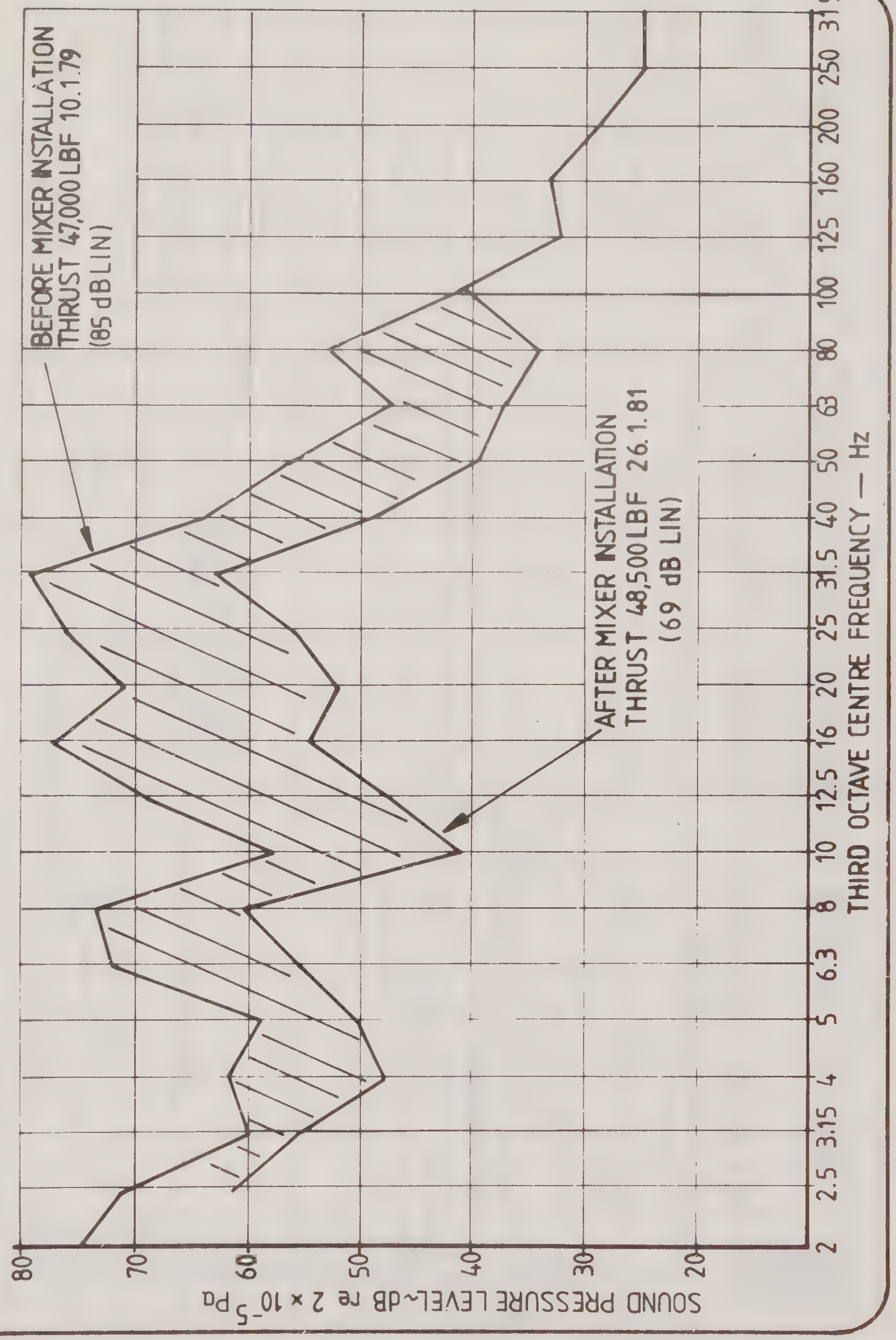


FIG. 6

TYPICAL NOISE SPECTRUM MEASURED 150 FT FROM INTAKE OF GAS TURBINE POWERED PUMPING STATION

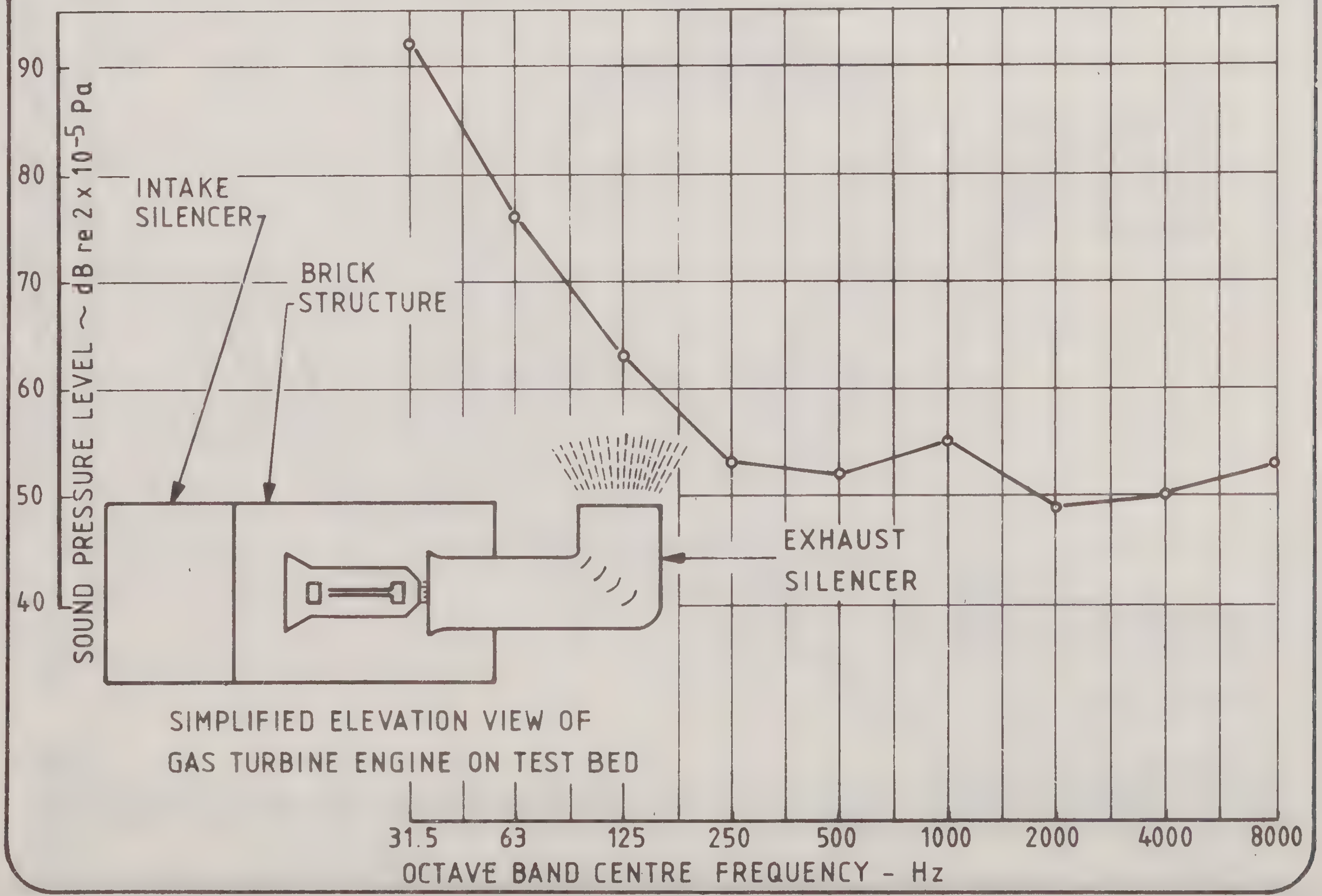
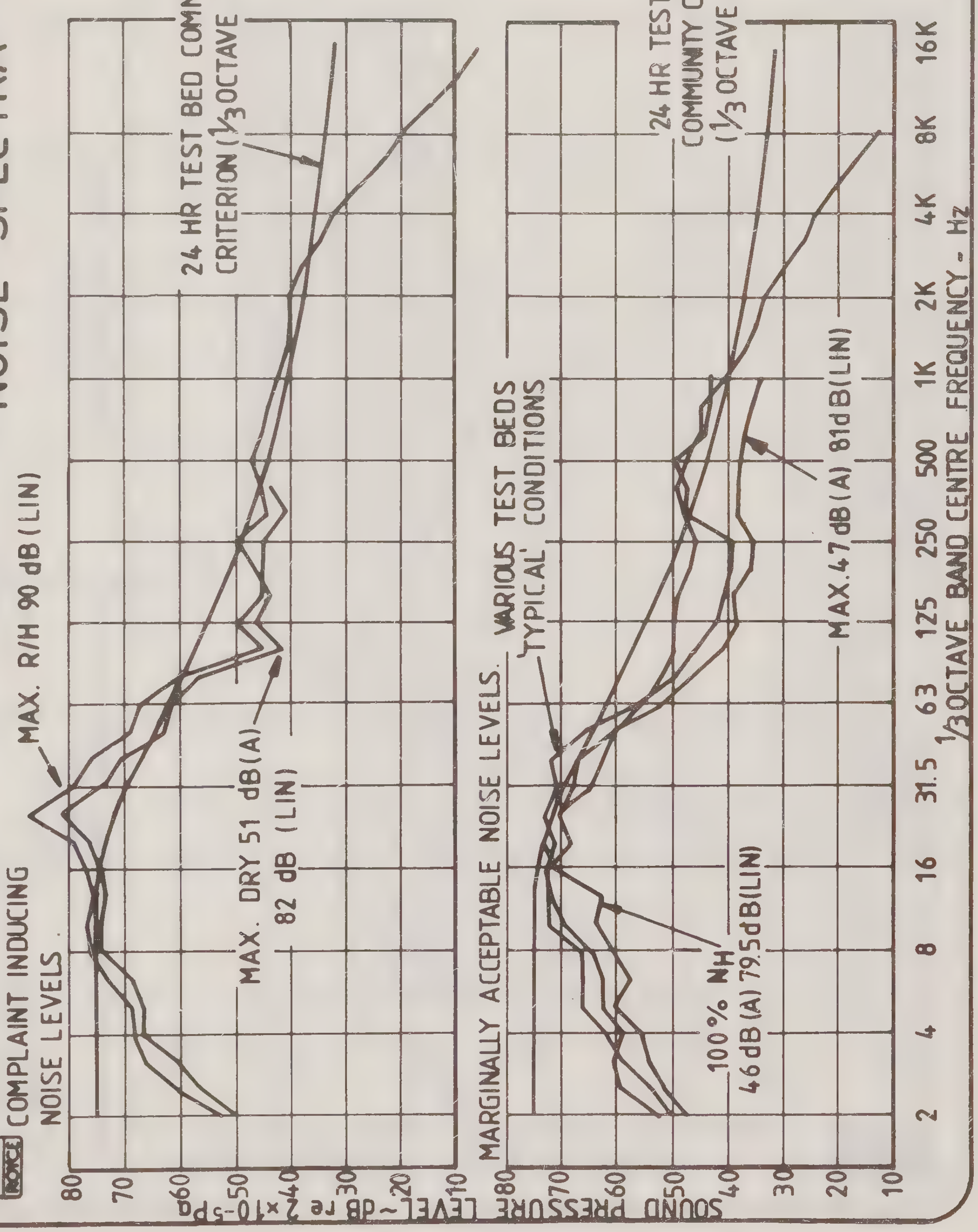


FIG.7.

COMPARISON OF 'ACCEPTABLE' & 'UNACCEPTABLE' NOISE SPECTRA



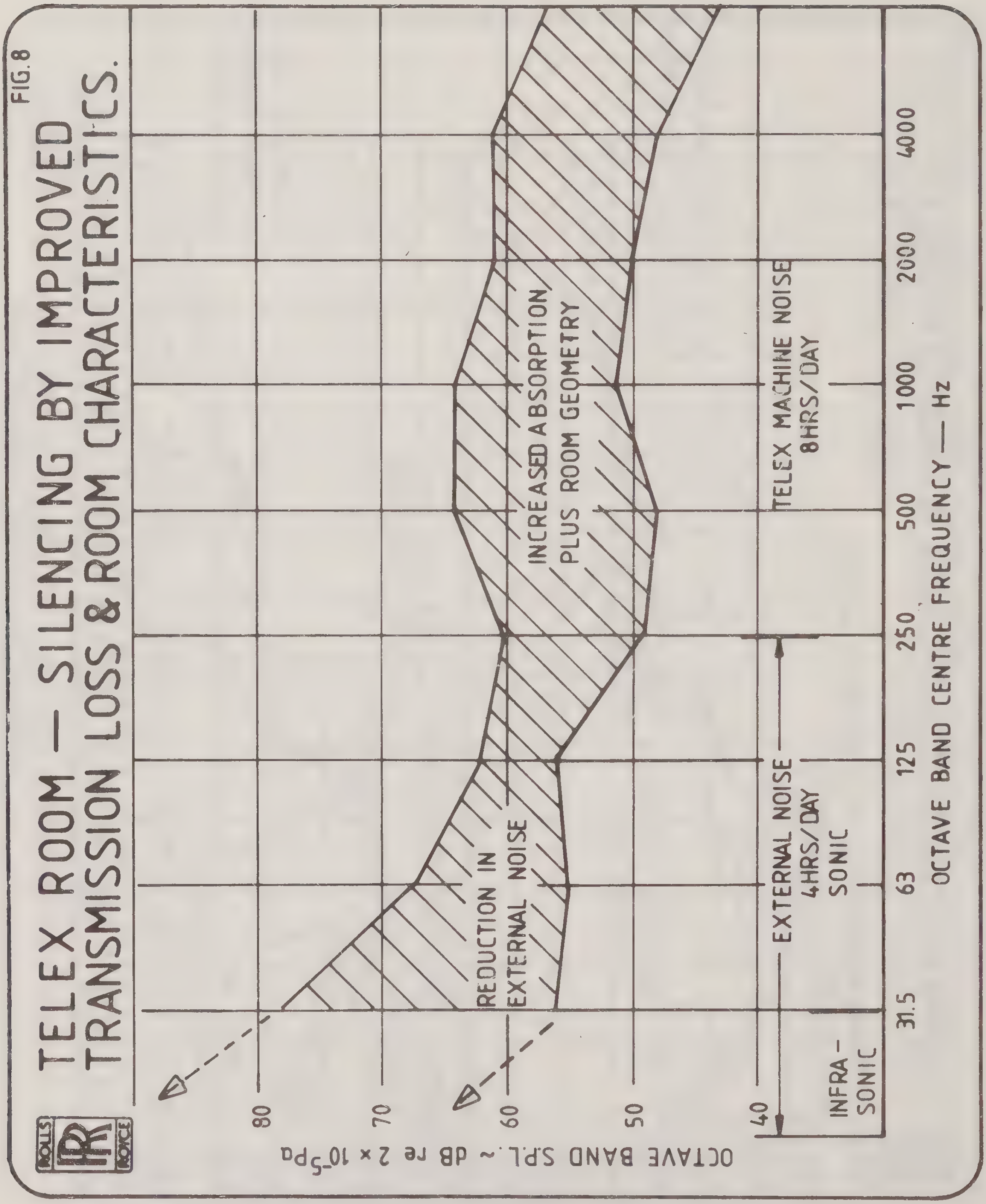
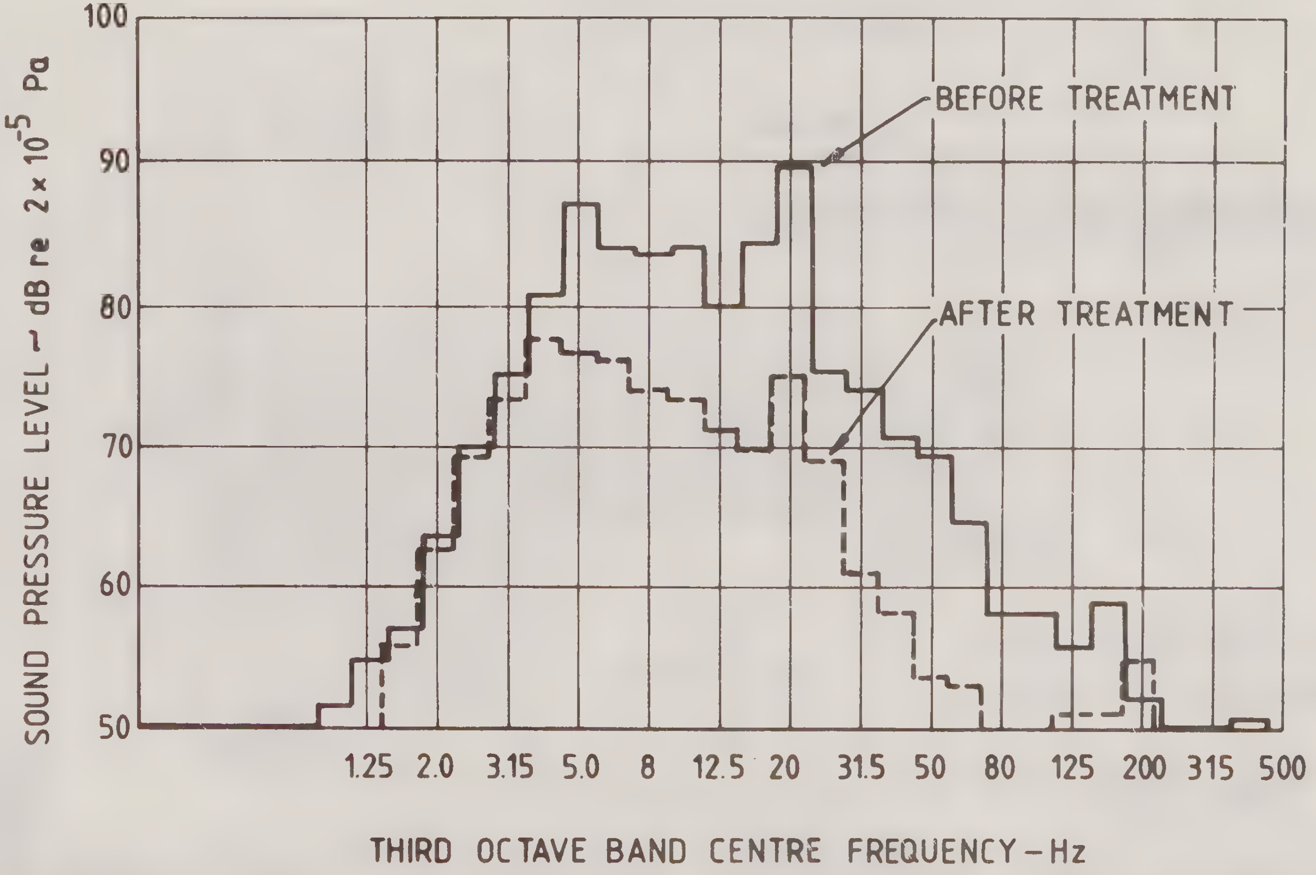


FIG. 8

TELEX ROOM — SILENCING BY IMPROVED TRANSMISSION LOSS & ROOM CHARACTERISTICS.

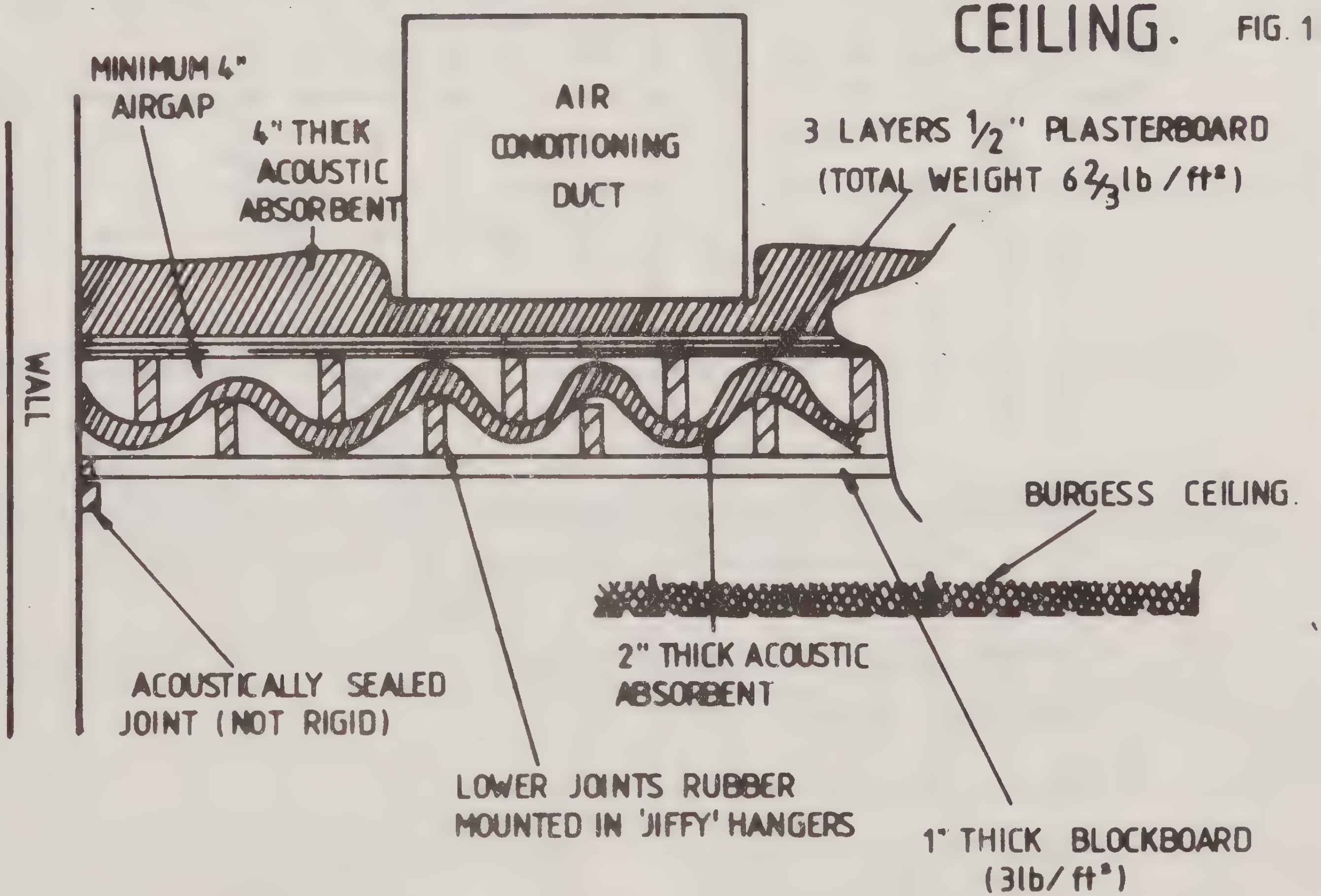
FIG. 9

VENTILATION FAN NOISE IN DISC CLEANING ROOM



NEW COMPUTER BLOCK ~ CONSTRUCTION OF ACOUSTIC CEILING.

FIG. 10.

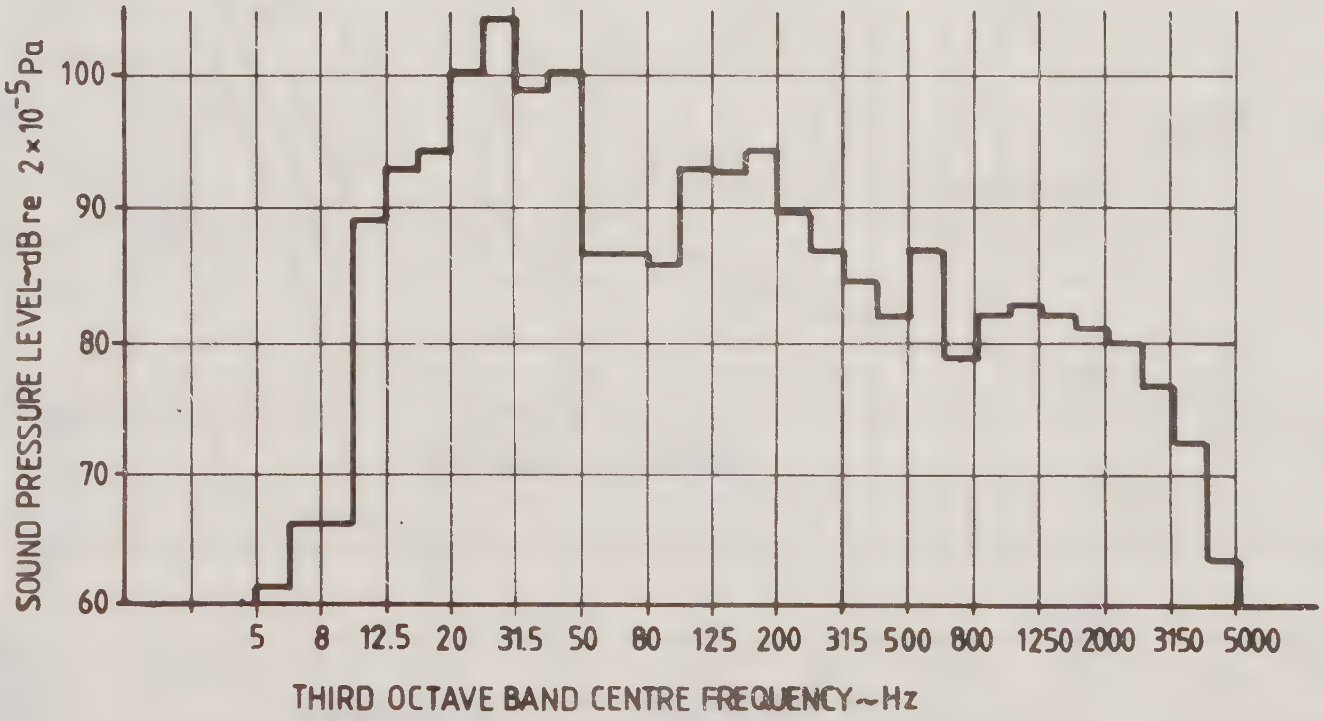

MINIMUM 4" AIRGAP
4" THICK ACOUSTIC ABSORBENT
AIR CONDITIONING DUCT
3 LAYERS 1/2" PLASTERBOARD (TOTAL WEIGHT 6 2/3 lb / ft²)
WALL
BURGESS CEILING.
2" THICK ACOUSTIC ABSORBENT
ACOUSTICALLY SEALED JOINT (NOT RIGID)
LOWER JOINTS RUBBER MOUNTED IN 'JIFFY' HANGERS
1" THICK BLOCKBOARD (3lb/ ft²)

NOTE:
THE STANDARD BURGESS CEILING WAS RE-INSTALLED BELOW THE ACOUSTIC CEILING SHOWN ABOVE.

FIG. 11

RECIPROCATING AIR COMPRESSOR 1FT. FROM INTAKE (ON LOAD)

109 dB (LIN)
91 dB (A)



DOMESTIC BOILER NOISE .

FIG. 12 .

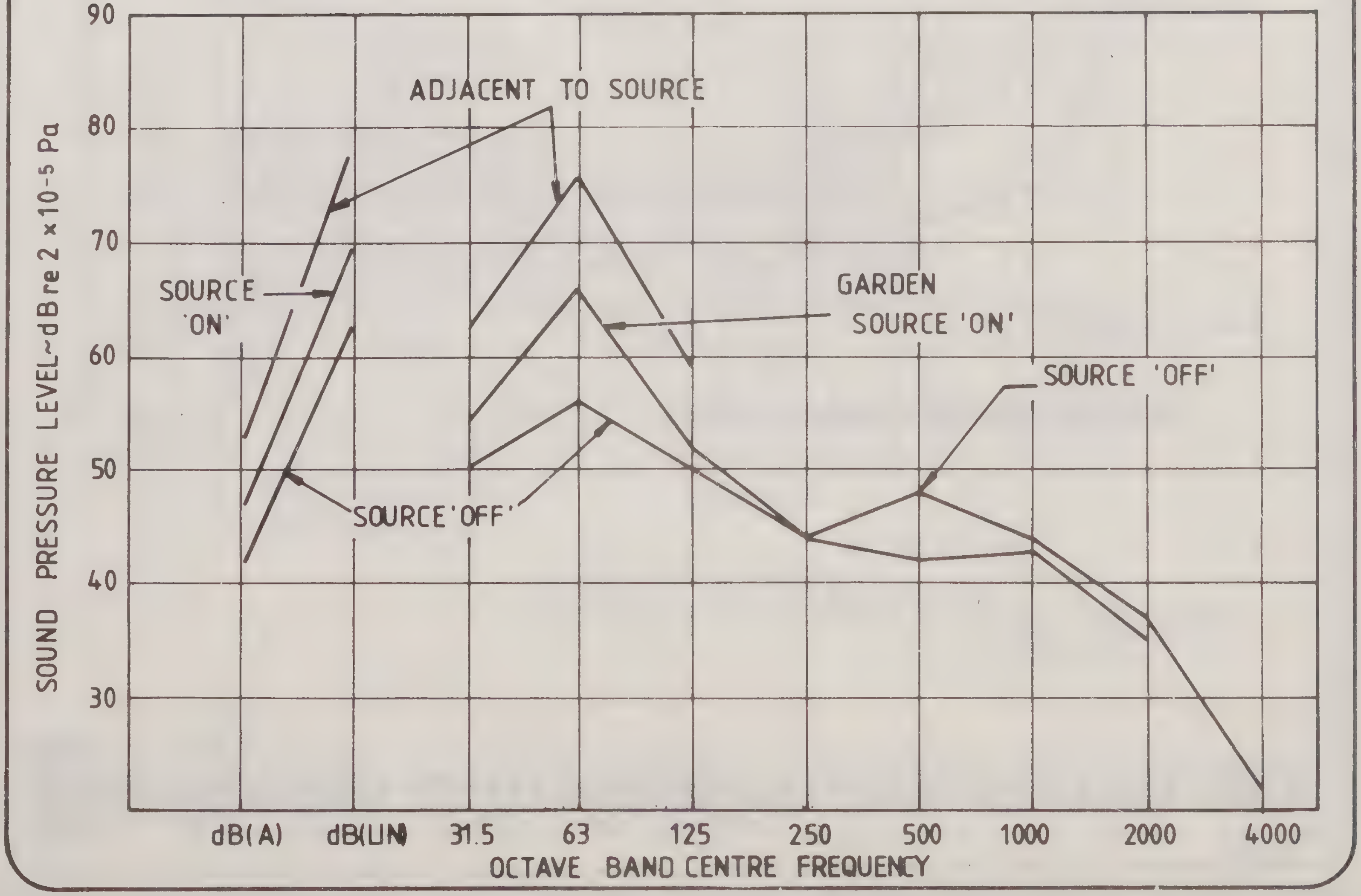


FIG. 13.

TYPICAL NOISE SPECTRUM MEASURED IN AN INDUSTRIAL BOILER - HOUSE.

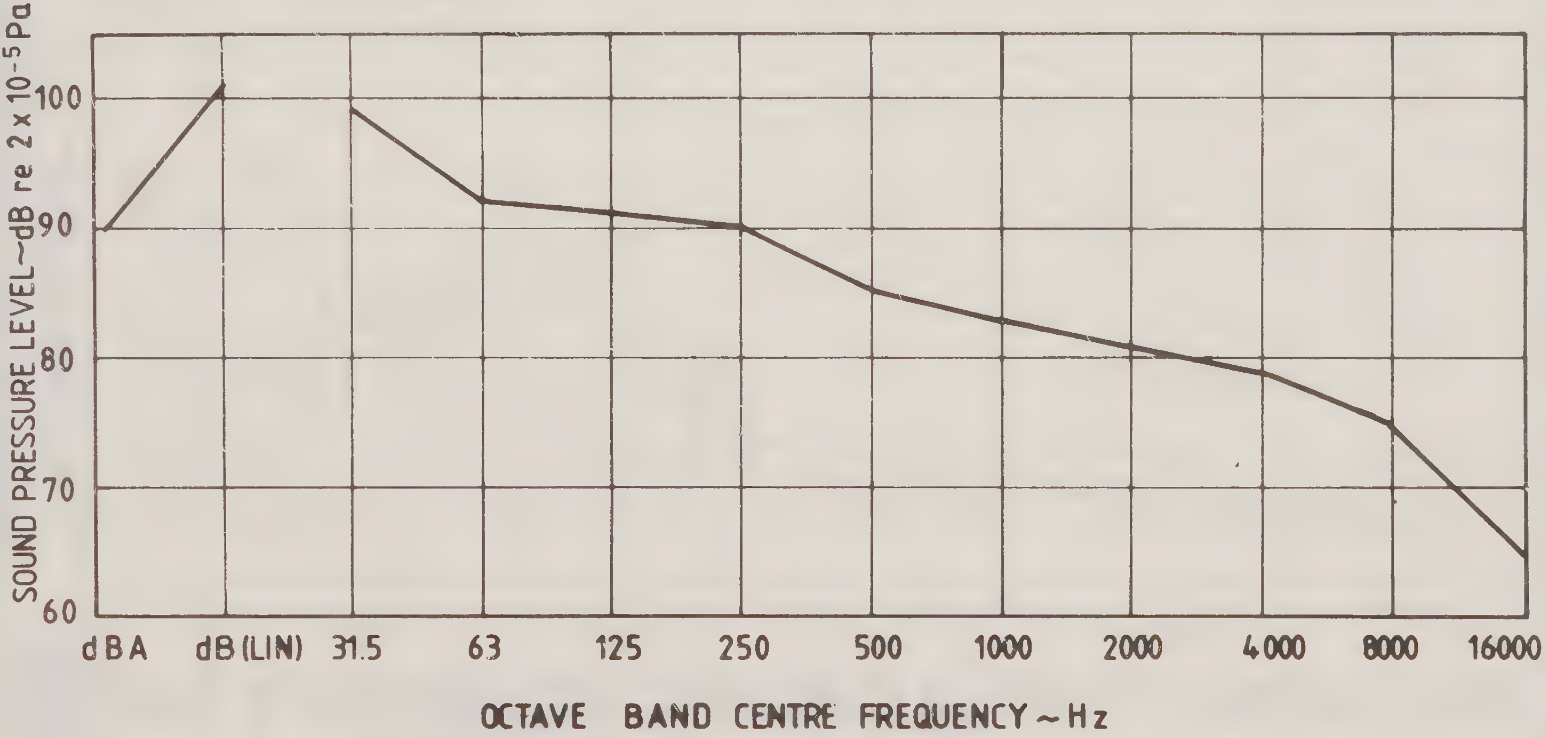


FIG 14

NOISE & VIBRATION ON CABIN DECK OF DIESEL POWERED SHIP

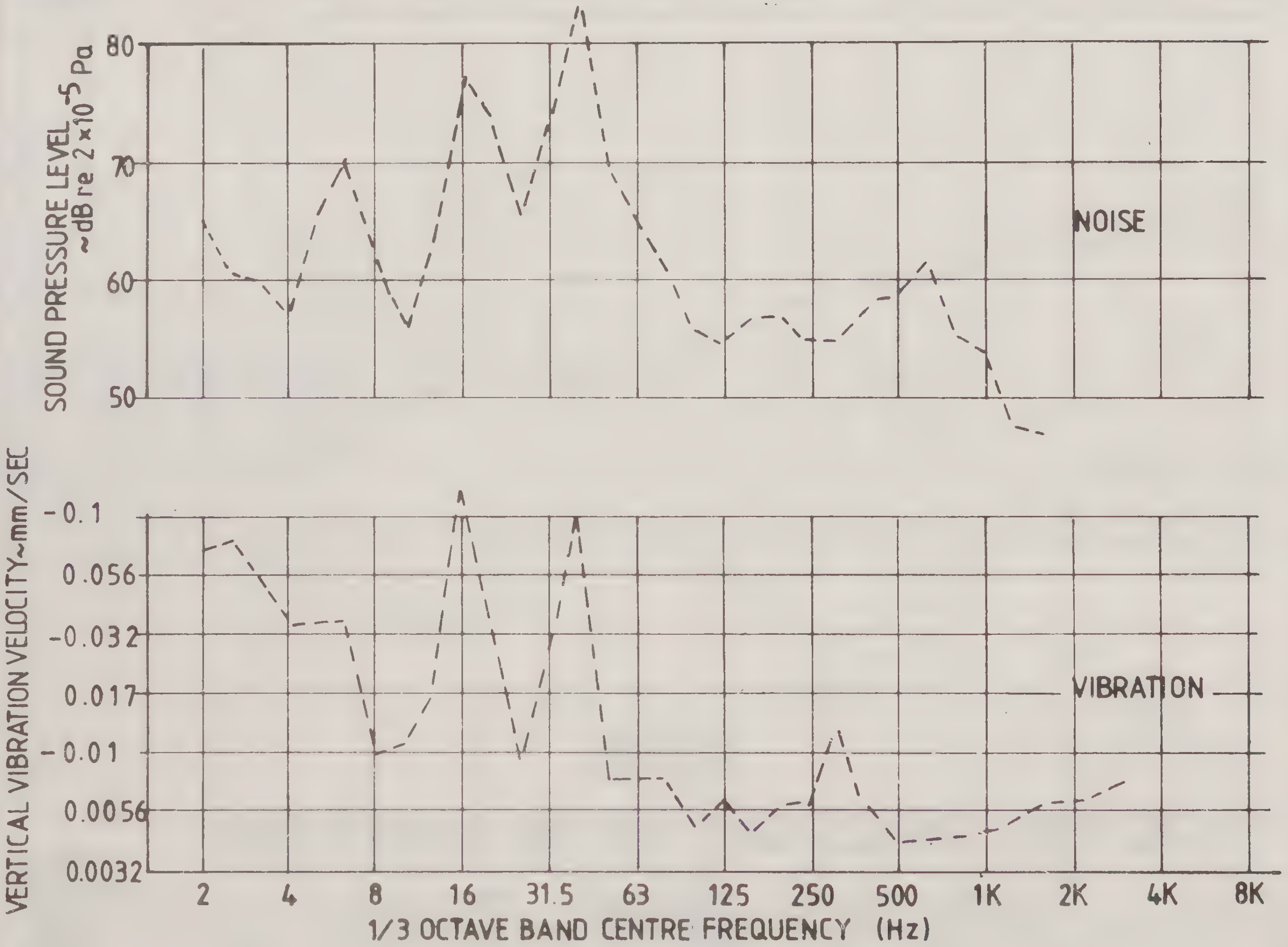
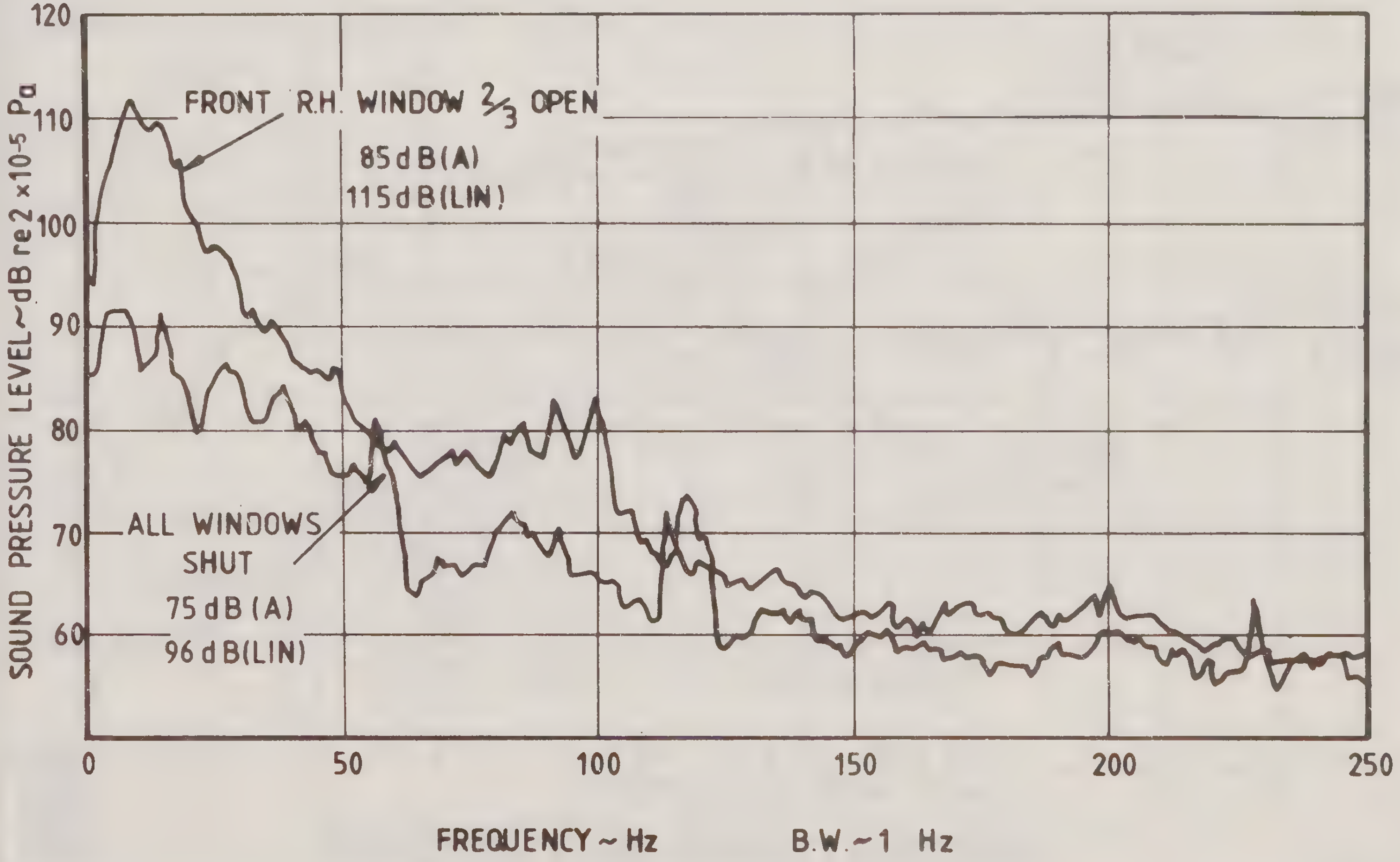


FIG. 15.

VEHICLE WIND THROB - WINDOW OPEN/CLOSED

SALOON CAR ~ 60 m.p.h.



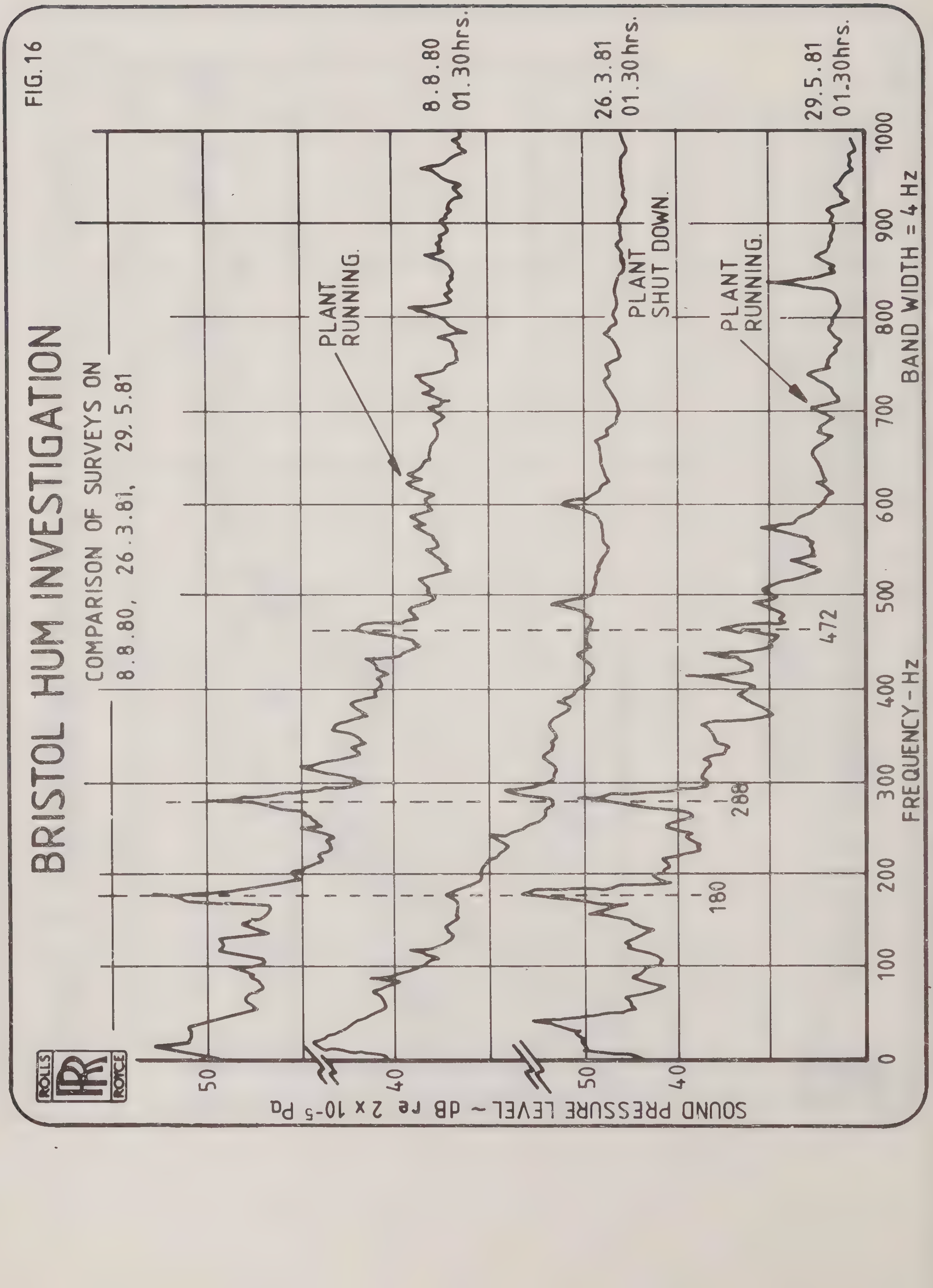


FIG.16

BRISTOL HUM INVESTIGATION

COMPARISON OF SURVEYS ON 8.8.80, 26.3.81, 29.5.81

FIG. 17

INTERNATIONAL STANDARDISATION FOR LOW FREQUENCY NOISE MEASUREMENT ~ WEIGHTING CURVES FOR DISCUSSION. (AFTER BRUEL REF. 14)

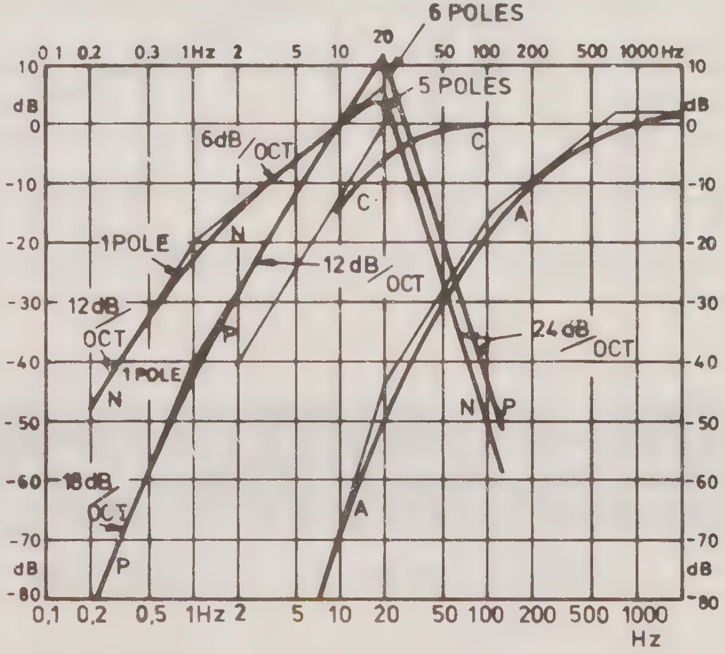


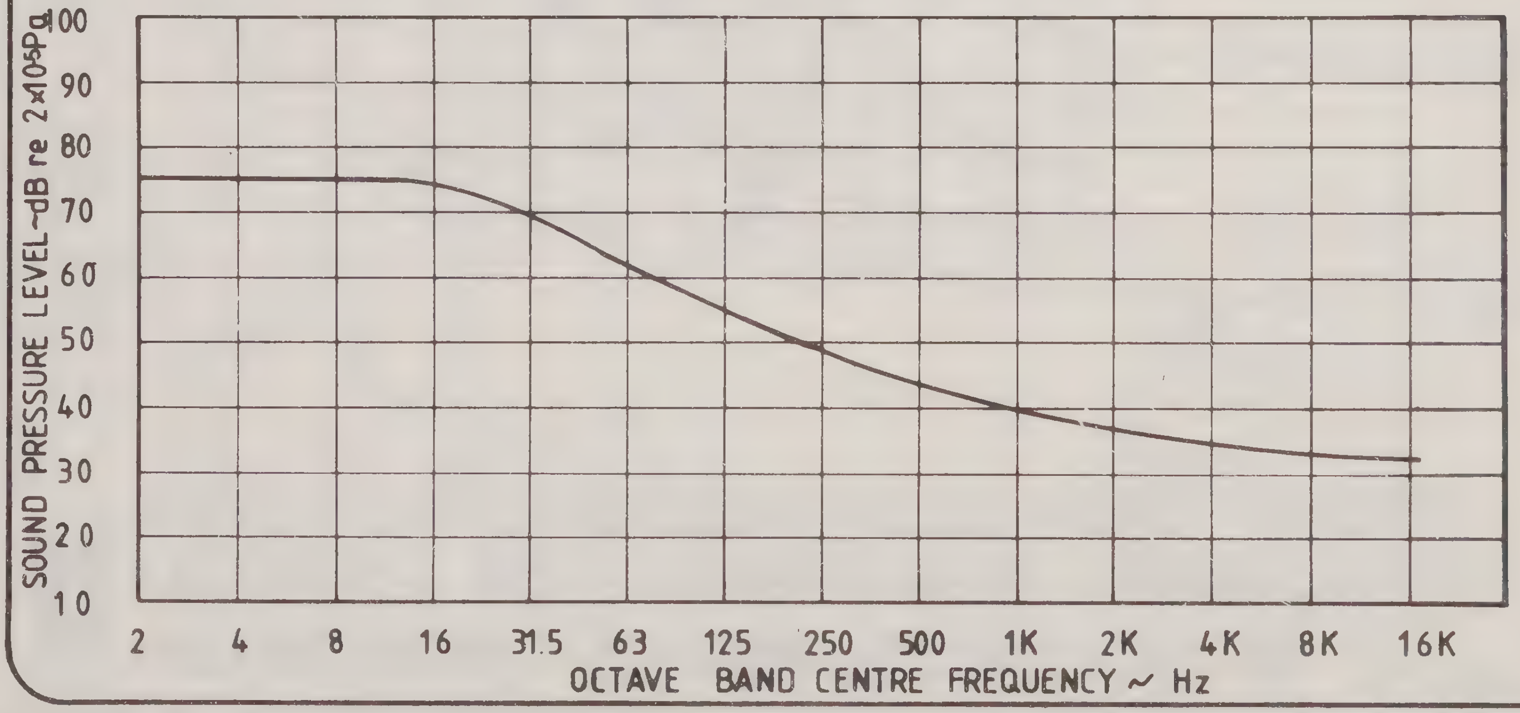
FIG. 18

COMMUNITY NOISE CRITERION

1/3 OCTAVE BAND ~ MEASURED AT THE NEAREST HOUSE.

2	2.5	3.15	4	5	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	1/3 OCTAVE BAND CENTRE FREQ.~Hz
75	75	75	75	75	75	75	75	75	74.5	73.2	71.8	70	67	64.5	62	59.5	57.2	55	52.8	SOUND PRESSURE LEVEL dB re 2×10-5 Pa

200	250	315	400	500	630	800	1K	1.25K	1.6K	2K	2.5K	3.15K	4K	5K	6.3K	8K	10K	12.5K	16K	1/3 OCTAVE BAND CENTRE FREQ.~Hz
50.8	49	47	45.5	44	42.5	41.2	40	39	38	37.2	36.4	35.8	35	34.2	34	33.2	32.8	32.2	32	SOUND PRESSURE LEVEL dB re 2×10-5 Pa



NATIONAL SOCIETY FOR CLEAN AIR

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5 - 8 OCTOBER 1981
BRIGHTON

PROBLEMS IN ASSESSING THE SUBJECTIVE EFFECTS DUE TO LOW FREQUENCY NOISE

by

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England

Concern over the effects of low frequency noise has grown apace with its increased incidence in the modern environment. The occurrence of low frequency sound has largely been due to the spread of sources such as: combustion processes, transport vehicles and compressors, to mention a few. Typical spectrum of these sources may be seen in Figures 1 and 2.

Traditionally, most of these sources would have been assessed only in terms of dBA, whilst it has been established that such conventional sites generate high levels of low frequencies (20 Hz-200 Hz), therefore it is not unusual to find SPL differences between dBA and dBC, or linear readings upwards of 20 dB (Leventhall, 1980).

It is not surprising to find that many questions have been asked about the usefulness of an A weighted standard, in terms of the validity of assumptions inherent in its use with respect to (a) the auditory system's full range of response and (b) the consequence of exposure to the frequencies which dBA attenuates, see Figure 3. Let us look at the argument.

The primary aim in developing a dBA system has been to make sure that the ear would be protected from any potential damage due to particular intensity levels of noises. In essence, the A weighting curve assumes the ear to be most vulnerable at its most sensitive state. If this were to be accepted, then the following argument, namely that, people were more likely to be disturbed/affected by intensities and frequencies lying within the curve would appear to be justified. Moreover, an operating characteristic of the dBA curve would assume that this definition of hearing acuity would serve to accommodate in general most noise-induced problems. Clearly with respect to high intensity noise levels, attention to the dBA scale can help to prevent damage to the ear. However, at the same time, it may fail to consider much which could be damaging to the person as a whole.

Current criticism of the habitual reliance upon dBA originates from a dissatisfaction with pure tone threshold measurements as being indicators of responses to exposure and a growing concern towards the understanding of the effect of low frequency noise exposures on the person as a whole. It would seem to be an appropriate moment to expand these points and to ensure their relevance. Therefore, it is necessary to illustrate what pertinent aspects have recently been developed in this field. For our purposes, they may be considered to be: (a) audiogram shape, (b) sensitivity peaks, (c) processing of auditory signals and (d) annoyance.

AUDIOGRAM

It should be considered whether the conventional pragmatic view of the auditory threshold response (as assumed in the dBA standard) may serve to limit our ability to solve some noise problems in the environment. This view is due to the predominant interpretation of the hearing process as being relatively static with some limits of change, with respect to middle ear transducer effects or adaptation/ fatigue inherent in the mechanics of a cochlea.

The process of hearing is derived from a biological process and as such will clearly contain a number of distinguishing characteristics in common with all biological systems, primarily that of variance, which is also a form of genetic population flexibility (Plotkin and Odling-Smee, 1979). There is little new in the fact that people's audiograms can reveal different levels of sensitivity (response) to, in most cases, pure tone spot frequencies. However, what needs to be emphasised is that, while such threshold tests are able to reveal the broad characteristics of a person's hearing threshold, i.e. a curve from 125 Hz (which is the lowest limit) to 8 KHz with sensitivity increasing with frequency, at least up to 5 KHz, much data is missing, such as the variance within the threshold existing between the spot frequency points. For example, as far back as 1958, Elliot observed peaks and troughs in audiograms using 10 Hz interval analyses through a range of audio frequencies. Kemp in 1980 confirmed these findings and sought to explain these sharp peaks and troughs. In brief, Kemp suggested that such a phenomenon could be due to emission energy generated by partial reflection of stimulus frequency energy coming back from its resonant 'place' on the basilar membrane. This would supply sufficient energy to induce middle ear excitation at the stimulus frequency, (Kemp and Chum, 1980).

Given that information about the auditory process has been overlooked or relegated, we must now ask again whether such information is significant. It has been suggested that the importance of such data is amplified when other research on the dynamics of hearing is brought to bear.

SENSITIVITY PEAKS

As an example, in 1979, Cohen and Schubert of Connecticut University investigated the micro-structure of threshold to see if observed changes in the loudness of a just audible continuous sinusoid of slowly varying frequency were the result of fluctuations in the detection threshold as a function of frequency change. Their results demonstrated large threshold shifts (upwards of 5 dB) occurring as a function of small increments of frequency. They concluded that such peaks in sensitivity were indicative of a "fairly steep-sided filtering process". Their procedure entailed threshold determinations being made at 10 Hz intervals, between 1100 Hz-1200 Hz and 1380 Hz-1550 Hz, (Cohen and Schubert, 1979).

So far, the evidence has pointed to an auditory system that is now known to contain both inter and intra forms of variance with the phenomenon of sensitivity spikes of a possible frequency dependent nature. The issue has been taken up by Frost (1980) of Chelsea College and again sensitivity spikes were discovered (e.g. at 1100 Hz) using a sweep pure tone presentation to elicit change in threshold, and then analysing threshold shifts over 2 Hz range along a 10 Hz band width. Frost argues that the quality and magnitude of the peaks selectivity suggests that Kemp's model would be unlikely to explain the phenomenon. One major observation being that the peaks were consistent in both amplitude and frequency. Incidentally, the loudness contours were found to level out as intensity increased which seems to be congruent with loudness discomfiture levels (LDL).

PROCESSING OF AUDITORY SIGNALS

There is ample experimental data available to indicate that even the physical characteristics of the hearing mechanism provide a range of complex features, such as ascending/descending thresholds, micro-structural phenomena, sensitivity peaks, adaption and fatigue (TTS). All of these characteristics could serve to cast doubt upon the effectiveness of an intensity oriented view of hearing.

Since the advent of such guidelines as the dBA scale, hearing has become operationally defined as a mechanism which has a sensitivity level; above which a stimulus of a given intensity would be detected (heard), while intensities below it would elicit no response and would, in terms of hearing, be redundant. These concepts are clumsy when attempting to develop a conceptual analysis of annoyance, caused by low level intensities.

So far, points have been made illustrating some of the problems associated with intensity/frequency aspects of hearing. The problems are compounded when we recognise the need to construe the auditory system in terms of its operations as an information processing unit. Some of these operations may be considered here under (a) listening and attention and (b) the decoding of speech.

Sound contains a range of characteristics all of which may serve to provide the auditory system with some form of data. Cues are generated from a sensory input, these cues are no longer purely sensory in nature and form the basis for the development of further information. Following this process, a response is chosen and carried out forming a behavioural link between the person and his environment. The individual is posed with the problem of making sense of, in this instance, the acoustic environment and this is achieved through an auditory continuum of contact ranging from sensory to psychoacoustical. Adopting this conceptual framework, it seems sensible to say that all sounds need to be interpreted by the person. A correct interpretation would facilitate an adjustment, aligning the person to the sound and the environment.

ATTENTION

Moray (1972) gives a review of research into this area and suggests that the dimensions which have been most exhaustively studied as bases for auditory selective attention are: (a) pitch, (b) loudness, (c) meaning and syntax and (d) positions in auditory space. The results of these experiments leads him to posit a distinction as existing between the masking of a quieter message by the louder message, and the use of the capacity to use cues of greater loudness as a function of selection. The results throw some light on the effect of attention on the strength of a signal and its potential audibility.

Triesman (1964) conducted experiments involving dichotic listening, which provided strong evidence for internal processing. She presented one message to the right ear, another to the left ear and a third to both ears. A laterisation phenomenon resulted in the messages being heard respectively at the right and the left and inside the head about the midline. Her subjects were able to shadow/report the third message.

Moray, again using dichotic messages imposed a command asking the subject to change ears, the command being contained within a prose passage. The instruction was heard in the attended message. Further, he paired a small electric shock with a 'neutral' word and even though not heard in the rejected message, conditioned GSR's were elicited at its occurrence.

Ellis (1961) using a listener's name and the names of other people as signals within a masking signal of white noise found that the threshold of the listener's name was lower.

Others have investigated K complexes in the EEG (a measure of arousal) during sleep periods, and hace noted significant responses in the form of increased activity in the readings as well as in GSR's as responses of the subject to his own name again embedded in a series of names, while remaining asleep, (e.g. Oswald, et al, 1960).

These results combined with Triesman's results clearly suggests that even non-attended stimuli are analysed by higher levels of the cortex.

In summary, Moray notes that the listener is more likely to respond to the complex cues within a rejected message, of which he is neither aware nor asked to monitor, that produces a switch in attention, rather than simple physical characteristics of a waveform. For example, simply making the rejected message louder made little difference to performance of the shadowing task. This is held to be so up to intensity level increases of 10 dB, Moray (1958). Moray concluded that it would be advisable to be receptive to a unitary theory of auditory functions as there are strong arguments (Swets, 1963) to suggest that there is little difference in operation between the selection of verbal and non-verbal signals. Attention, voluntary or otherwise, provides us with yet another area of powerful flexibility to be found in our hearing mechanism. Moreover, it is a flexibility characterised by: dual processing, threshold shifts responsive to content and not intensity alone, centralised decoding and evaluation; all of which are able to provide the individual with a response with which to locate himself along a continuum.

Examples have been outlined which demonstrate the difficulty in interpreting the auditory system's response in terms of intensity. We now take note of problems concerned with frequency content. Such problems are manifested in the study of speech perception.

SPEECH PERCEPTION

At the Bell Telephone Laboratories, experiments were conducted into the importance of frequency range/content for the cognition of speech. Using high, low and band-pass filters with variable cut off frequencies, they demonstrated that no particular frequency components were essential for speech recognition. For example, the experiments using band-pass filters showed that even a narrow band of frequencies, e.g. 1000 Hz-2000 Hz, would be sufficient for speech recognition.

The phenomenon known as the "pulsating threshold" reported by Warren (1970) provides an example of a person hearing a word even when acoustic cues are minimal or non-existent. The emphasis on hearing, in this instance, is placed in a linguistic context and the capacity of the system to establish "transitional probabilities" between one word and the next, (Cherry, 1953). In short, while acknowledging that speech perception is a specialised area closely bound to linguistics, it is evident that the acoustical waveform known to us as speech is processed accurately by our auditory system, withstanding large amounts of background noise, severe filtering, peak clipping or interruption.

So far, a brief outline has been made of (a) physical aspects of hearing and (b) relevant cognitive operations, in an attempt to expand the concepts of hearing. The next stage considers the individual's physiological state as a consequence of the auditory system's detection, processing and response to noise, or a given signal.

The physiological effects of high intensity (50 dB and above) and audio-range frequencies (and above 4 KHz and below 20 Hz) have been well documented (see Davis, 1958; Kryter, 1970 and Schaudinischky, 1976). At this juncture, it would seem appropriate to now focus our attention more fully on low frequency noise effects.

PROBLEMS WITH LOW FREQUENCY NOISE CRITERIA

Having established that noise criteria are often thought to be inadequate when dealing with low frequency/low level noise, we should look at the reasons why this is so. This is due to the fact that annoyance is a complicated response as much related to cognition, intensity, information content and selection processes, as to any other characteristics.

The role of low frequency noise has therefore been placed in an interesting position. For example, changes at low frequencies might be easily perceptible, yet have a negligible effect on the dBA level. Further, as Leventhall (1980) notes, it is feasible to reduce dBA level while adding to the sensation of loudness. This can be accomplished by simply shifting the noise energy out cf dBA levels, and into the lower frequency range.

Low level/low frequency noise tends to become annoying in the absence of higher frequencies, which serve to mask its effect. This is a common occurence as low frequency sound waves propagate over long distances, while high frequencies may be attenuated rapidly.

The problem of signal processing is evident here for subjective response to low frequency noise which varies, as do intra and inter-individual thresholds.

A problem which has yet to receive an acceptable explanation is the phenomenon known as "tuning in" or "attending" to low frequency stimuli. Most sounds, given a long enough period of time would cease to be a problem due to habituation. This is a joint effect based upon auditory adaptation and selective attention. However, many people who complain about low frequency noise describe how they "tune in" to the signal and how its "loudness" grows. This may be related to the attention factors observed by Moray (1972), where an increase in sensitivity equivalent to 7 dB was found. Further, it should be remembered that phon levels tend to converge noticeably at lower frequencies. Any sensitivity peak or shift down could bring about a doubling of loudness for only 5 dB. If the "tuning in" symptom persists, then physical symptoms commonly ensue. The symptoms are similar to those associated with stress, e.g. headaches, pains in the neck, arms, legs, digestive disorders and restless sleep periods.

Hopkins (1976) reports that a person is more likely to be drawn out of REM sleep by low frequency noise than by any other type of noise. Again the conclusion tended is that the ability of the brain to process low frequency noise and to maintain REM is reduced due to the characteristics of the sound.

Recently, Tokita (1980) investigated complaints about low frequency noise (2-90 Hz) which were predominant at SPL's as low as 65 dB. The complainants exhibited symptoms of sleep disturbance, irritation, headaches and a sensation described as "oppressive" and heavy. These symptoms seemed to diminish with an increase in SPL. This again makes little sense in terms of a dBA conception of annoyance.

The data so far presented gives sufficient reasons to show why it is felt that research is called for in the establishment of valid low level/low frequency criteria. Rather than fall into the pitfalls outlined in this paper, Chelsea College has developed a planned exploration into low frequency phenomena. We aim to get a more complete picture of the characteristics previously discussed. For example, we know that in the region of 1 KHz-1500 Hz thresholds may vary by as much as 15 db over a range of 20 Hz. Perhaps the lower range (20 Hz-200 Hz) may yield similar features. Therefore one project at the moment is a full micro-structural analysis of the threshold 20 Hz-150 Hz. For details about this project, see Appendix A.

Other projects include:

i) Deriving data for weighting of spectra transmitted through various walls and assigning the appropriate frequencies annoyance values. Mr. Breitz is conducting postgraduate research in this area using a scale model technique.

ii) Assessments of the body's physiological reaction to low frequency. This involves the presentation of a variety of low frequency noise sources during which the subject has to work through a number of conditions, e.g. task performance.

Physiological measurements include:

- heart rate variability
- selected parameters include the QRS complex:
    - respiration
    - blood pressure
    - thermoregulatory responses
- GSR
- Hayre voice stress ratings

To summarise, an attempt has been made to outline some of the complexities involved in making an assessment about the type and magnitude of effect that a given noise source will have upon an individual. Some of the evidence has been reviewed concerning the auditory system's potentials. Comments have been made about biological variance, micro-structure, sensitivity peaks, information processing, attention and finally physiological responses to low level stimuli. These characteristics of hearing have served to illustrate the active nature of audition and its full capacity to extend the system in terms of its response to sound. This function clearly being the result of both physical and psychoacoustical properties of the ear.

In conclusion, it is clear that in order to establish viable noise criteria, it will be necessary to develop a cohesive overall model of hearing. Audition functions actively/passively on a number of dimensions that form a contract point between the individual and the environment, ranging from pain thresholds, to situational cues and physiological states.

The increasing incidence of annoying low frequency/low level noise indicates the need for the expansion of existing criteria. The dB(A) scale has already undergone radical criticism and changes have been suggested. The next step will probably lead into full investigations into low level/low frequency noise and the problem of annoyance, and the factors which may serve to minimise/increase an individual's annoyance.

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APPENDIX A

APPROACH AND AIMS

(a) Measurement of hearing threshold from 20 Hz - 150 Hz using steps of a ratio $\frac{F}{10}$ Hz (or smaller).

(b) Allow the subject to control, manually, sweep through frequency ranges where peaks were indicated. Loudness matching would be used to estimate the growth in sensitivity. An analysis of results should facilitate a detailed outline of:

- i) Low frequency threshold shape.
- ii) The existence of sensitivity peaks and their location.
- iii) i) and ii) should combine to illustrate threshold peaks shape with respect to the general threshold.

EXPERIMENTAL CONSIDERATIONS

There follows an outline of the major problems that required attention in order to maximize the possibility of obtaining valid measurements.

QUALITY OF SIGNAL

1) Harmonic distortion.	Below threshold points. Ratio 3:1
2) Background noise level	
3) Electrical noise - peak/trough	
4) Signal to noise ratio.	
5) Impedance.	Input/output matched.

VIBRATIONAL INTERFERENCE

1) Isolated chamber.	Vibration reduction of 6 dB to 3 dB.
2) Booth base stabilized	
3) Booth	

MAINS INTERFERENCE

1) Screened leads	Mains hum at 50 Hz below threshold.
2) One earthing point	
3) Equipment earthed	
4) Battery operated micro. amp.	

HEADPHONES (High quality Moving Coil)

1) Resonant frequency.	Resonant frequency 270 Hz weighted at lower frequency range - therefore reducing energy needed to drive them and therein level of possible distortion.
2) Distortion of signal due to characteristics.	
3) Accuracy of headphones.	
4) Liquid fitted ear pads.	
5) Headphone-microphone link for communication.	
6) Purpose-built clasp/support for probe microphones.	

MONITORING OF SIGNAL

1) Twin probe microphones.	Allowing monitoring of exact SPL at ear canal
2) Linearity of probe microphone.	Tested on artificial ear.

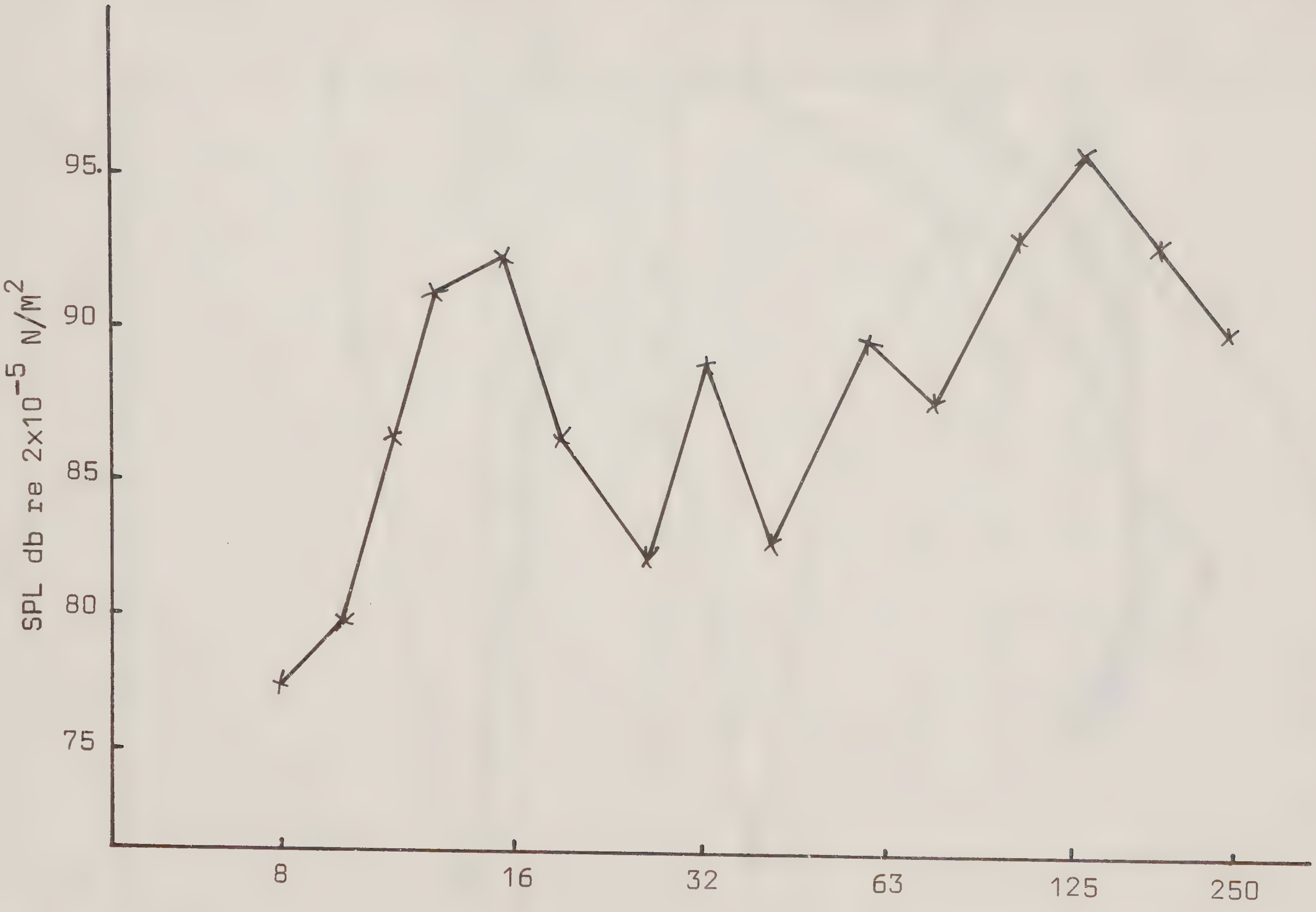

Figure 1

COMBUSTION NOISE

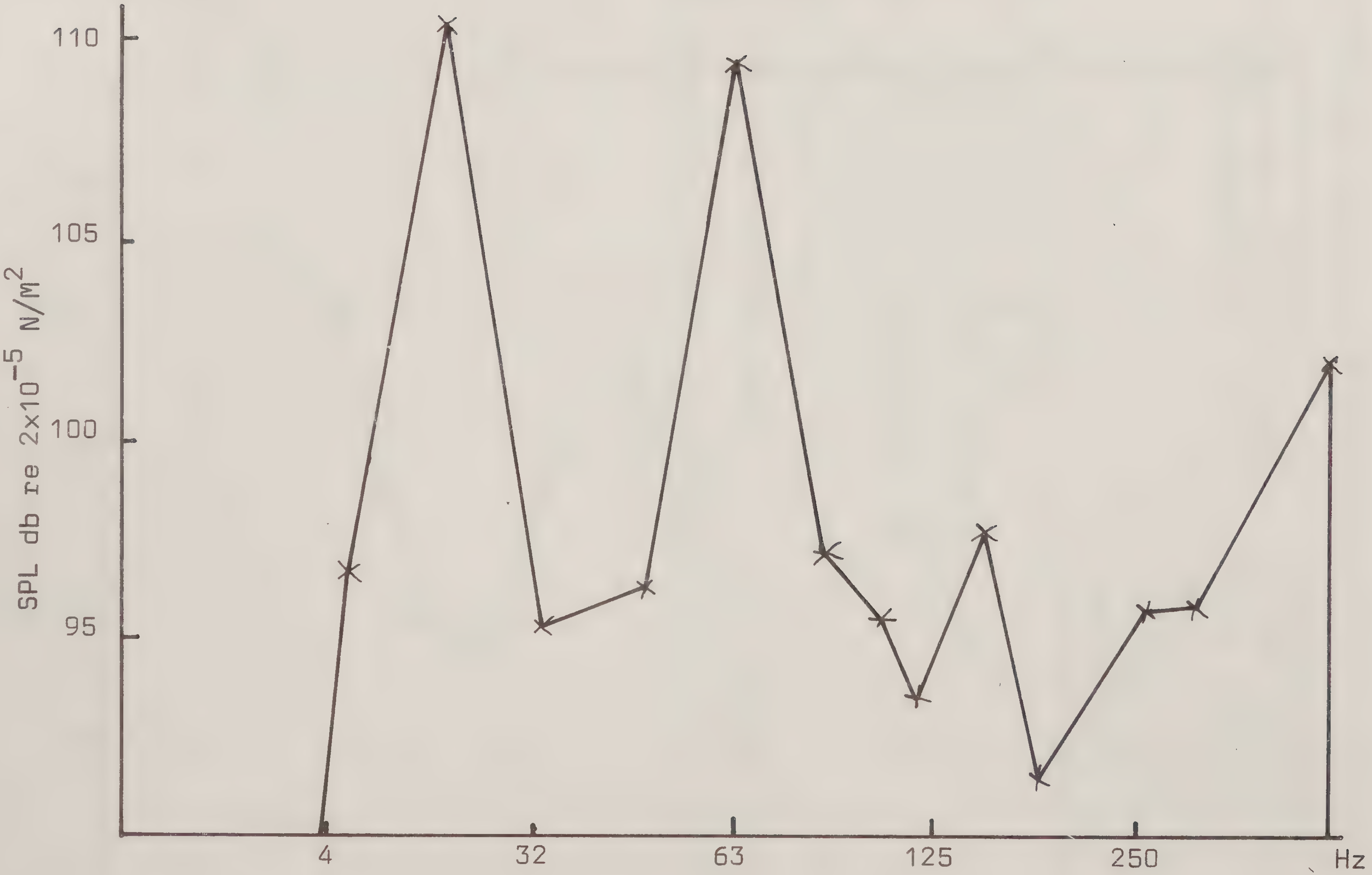

Figure 2

COMPRESSOR NOISE

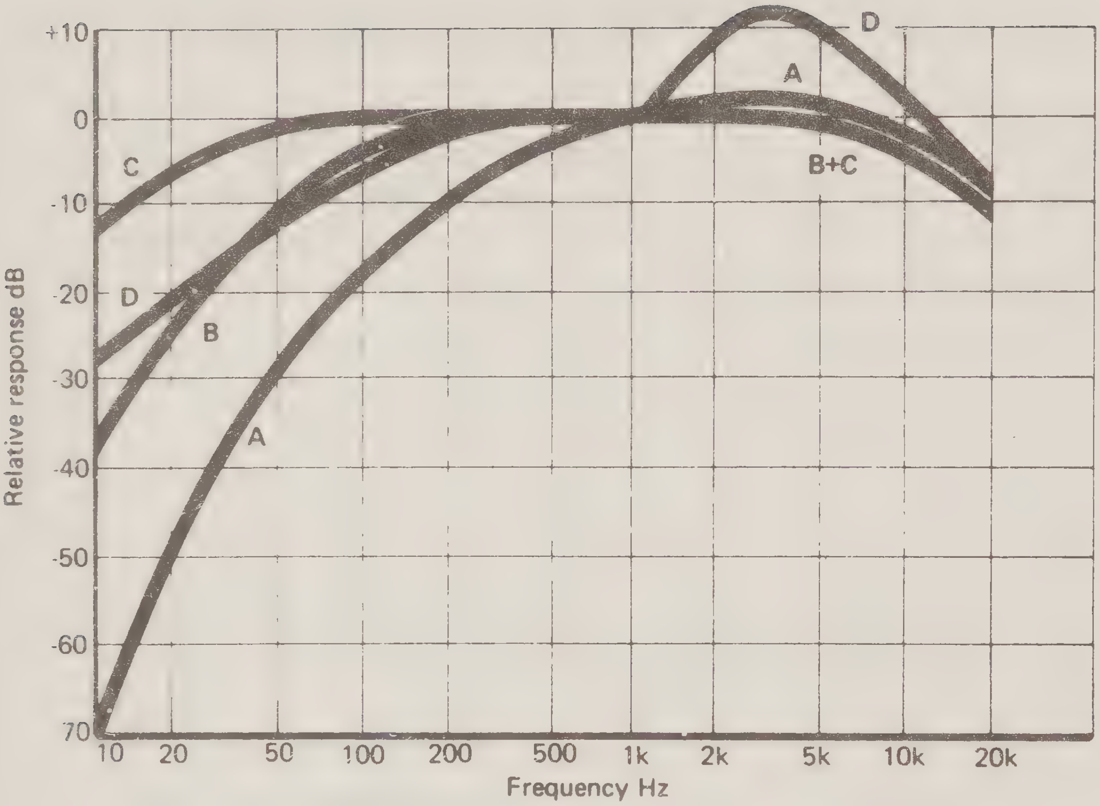

Figure 3
GRAPH SHOWING WEIGHTING CHARACTERISTICS PROVIDED IN ALMOST ALL SPL METERS (A CURVE IS GENERALLY USED WHEN MEASURING ACOUSTIC NOISE)

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AIR-POLLUTING ODOURS - CASE HISTORIES

by

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Air-polluting odours - what are they? We all know what an odour is - it's a smell. Air pollution is rather more complex. For present purposes we can say it is:

> The emission by man into the atmosphere of substances which have an adverse effect - in this case an odour.

The emphasis is on the word 'adverse' with the implication that if there is no adverse effect there is no pollution.

In the case of odours there then follows the definition I have given to this Society before, namely:

> "A bad smell is a detectable odour"

Thus if as a Society we wish to press for clean, unpolluted air our target must be to have matters arranged so that no polluting odours can be detected.

Virtually this means elimination at source but evidence over recent years indicates that technology has not yet always made this possible. Much experience has shown this and more recently the splendid work by Warren Spring Laboratory has for the first time shown how difficult it is to achieve the very high removal efficiency necessary for some of the very smelly substances using the methods we have heard of over the years - absorbtion, adsorption, catalysis, ozonisation and so on.

Thus it would seem that the Society must accept for some time yet that its ideals are not achievable.

Broadly-speaking the potential pollution sources fall into one of two categories - they either fall within the ambit of the Alkali Inspector or when they do not they fall in the lap of the Environmental Health Officer under the Public Health Acts.

The former's areas of management are describable as "large scale chemical industry" and the latter's as "smaller scale industry" which as well as including what the phrase implies includes sewage works, traditional industries such as offal treatment and agricultural practices.

In both cases, after all "Best Practicable Means" using the quotation marks quite deliberately there is left after much commendable work and resource expenditure, an "insoluble residue".

Motoring down the M1 one can tell blindfold the existence of the steel industries of Sheffield and Derby and when one is passing through the brickworks area of Bedfordshire. These are the province of the Alkali Inspector and the solutions are simply unknown.

Similarly the presence of the sewage works, the pig farm, the gloriously described processes of Section 107 of the 1936 Public Health Act:

> "Blood boiler, blood drier, bone boiler, fat extractor, fat melter, fellmonger, glue maker, gut scraper, rag and bone dealer, size maker, soap boiler, tallow melter or tripe boiler"

in many cases can be olfactorily detected. Not included in the "Registrable Works" or as defined above is a whole ancillary of smell-producing activities.

In any particular case the question is essentially whether the odour emission is indicative of either:

i) non-employment of the BPM (the classical, legal and flexible "best practicable means")

or

ii) whether the strength, character and frequency is such as to constitute a "Statutory Nuisance" within or without the legal implications (ie whether or not it is judged "adverse" in the terms of the initial definition).

In situations where it is uncertain whether anything can or should be done the assessment must be in terms of:

strength
frequency
objectionableness

The question posed is whether the sum of these is such as to warrant resource expenditure on their elimination or reduction.

This is the question - to say whether the smell must be tolerated or not.

It leads to the rider of "Who is the judge?"

In the case of large-scale industry as exampled by the brickworks and extended to the registered process of chicken-feather treatment it is the Alkali Inspector who has to fall back on the fact that the BPM may not allow of a no-smell solution and where this is reasonably certain some occurrence is inevitable. Until new technology is invented this is virtually the end of the matter.

In the case of the wide spectrum of non-Registrable Processes it is the Environmental Health Officer who is the "Man-In-The-Middle". It is he who has to decide whether the odour occurrence should be classed as a Statutory Nuisance or not. The law on the matter provides but little guidance and clear-cut answer, as those familiar with Sections 91-100 and 290 of the 1936 Act will recognize all too well. Does the strength, frequency and objectionableness warrant statutory pressure or not?

In this situation the position of the EHO is undeniably unenviable; on the one hand he has the sometimes nearneurotic complainants and on the other the knowledge that short of stopping the process there is no practicable means of elimination and the costs of litigation may have to be borne by his Council.

On this question of whether a smell occurrence situation is a "true nuisance" - sufficient to be classed as a Statutory Nuisance it is of interest to quote one of the results of a comprehensive survey by Mrs D Artis in a thesis for LIB "An examination of the law governing odour emissions" (Manchester University.) Sixtyfive Environmental Health Departments answered a questionnaire on odour occurrences in their areas. It is notable that from 12 kinds of classified sources of non-registrable type the number of occasions on which smell occurrences had occurred and were considered to be Statutory Nuisances was about half the number of occasions on which the odours were actually noted.

As the law stands at present this means that the occurrences of some odours must be tolerated and this is not a bad judgement taking everything into account.

The science and measurement of odour being as it is at present it is argued elsewhere (Ref.1) that "no precise law is better than bad law".

With this background let us go on to consider the title of this paper, namely case histories.

One "classic" smell occurrence may be said to be the "Teeside smell" (the Alkali Inspectors' words of the 1950s, perhaps ancient history but equally important as being an example of an odour due to one identifiable chemical species - the converse of most other cases).

At this time Teeside was inundated with an odour of tom-cats' urine - no other phrase is applicable. People to the south-west of ICI Billingham protested most understandably and vociferously but investigations by that company showed that the smell never occurred until the wind had carried from their works AND across the River Tees thus indicating the real source as the river. A protracted investigation worthy of the best scientific novel, too long to be other than summarised here, revealed the joint causes as a) a constituent of a new aqueous process effluent and b) the existence of gross pollution in the river giving rise to hydrogen sulphide --itself obnoxious enough but insignificant compared with the reactant product of the two materials.

This may be expressed chemically:

Acetone Production Plant

↓

Aqueous effluent containing some mestyl oxide

+

Anaerobic River

↓

hydrogen sulphide

→

Tom cat smell

$$(CH_3)_2C = CH.CO.CH_3 + H_2S \rightarrow (CH_3)_2.C(SH).CO.CH_3$$

It is interesting to note that this chemical had been made in 1894 but understandable that little further work was done on it!

Publication of the results was delayed as it was feared that the chemical expertise to produce large-scale stink-bombs was within the capability of any sixth-form chemist; when however it was published by T.J.P. Pearce et al a flood of similar occurrences came to light and the potential reaction between unsaturated ketones and hydrogen sulphide remains well worth watching for as the cause of related odours.

The cure in this particular case was chemically easy though costly - saturate the ketone by chlorination before discharge to the river.

In the above case the odour was reliably reported 40 miles away by aviators and Eggleton (1969) at a distance of 8 miles. An even greater travel was noted in Durban, where circulatory winds took the odour from a paper mill out to sea and returned them to the coast causing a nuisance in the city - a total travel of 40 miles. This says something about the virtually unqualifiable effect of meteorological conditions.

At the other end of the scale a case known to the author concerned "Brussel Sprout Blanching" - effectively the kitchen preparation of the Sunday lunch. We shall all of course, recognise that multiplication of the scale will have a wider effect. In this case the blanching of sprouts prior to freezing was carried on - to the tune of about 1 ton of sprouts per hour - and the homely odour spread for a distance of a quarter of a mile in some weather conditions. Under pressure the company moved the operation to another area.

The point of mentioning this case is that here we have a "domestic" industry, operating only in the Brussel Sprouts harvest period and having a small number of people objecting to the consequences. Had the operation not ceased what should have been done?

A further example of an odour problem was one arising from treatment of a brewery effluent - and for this case we are indebted to Bass Brewing (Runcorn) Limited and should acknowledge their co-operation through Mr. Paul Adams as co-author.

In 1971 a large brewery was built at Runcorn and arrangements made to treat the inevitable water arising from the operation prior to mixing the domestic effluent from the area in a co-operative scheme between the Local Authority (as then operative) and the Company.

Unexpectedly the effluent treatment section gave rise to an initial problem of an air-polluting odour. The odour which arose was quite nauseating in character. Complaints from a nearby village were voiced and the subsequent history, investigation and development of a solution is much too long to detail here. The following summary must serve.

The odour arose from two sources:

i) The anaerobic reactions taking place in the standing waters - the usual Primary Settling system and the various mains, and

ii) the biological changes occurring in the high-rate filters for reducing the Biochemical Oxygen Demand. Operationally these are plastic grids down which the water flows with an upcurrent of air - a most effective way of releasing any odour from a liquid.

Operating difficulties were also experienced and major modifications were carried out mostly with the joint aims of solving both problems such that complete segregation of the costs is impossible, but an assessment is presented in Figure 1 along with a dated list of the steps taken to investigate and attempts to cure the problem in Table I.

The graph Figure 1 shows the number of complaints per annum, numbering initially 81, and the capital expense in modifications graphed cumulatively through the years to the elimination of complaints to mid-1981 (the time of writing). The total expenditure of almost one third of a million pounds will be noted but this does not include the revenue expenditure, or that on the remedial measures taken shown without costs in Table I.

It is proposed that these data should speak for themselves; examination of the Table will show the many steps taken to avoid the development of the odour or its spreading, each probably bringing its own contribution to the solution! Basically three approaches were taken; reduction of anaerobic residence time, injection of oxygen and odour suppression stages.

There are five items of particular interest:

i) the trials of odour counteractants. Briefly these were tried and found wanting; of this more anon.

ii) A switch from sulphuric acid to hydrochloric acid for regeneration of ion exchange resins. The reduction in the amount of sulphur, from 600 to 20 ppm, to contribute to sulphidic odours achieved a significant though unquantifiable improvement.

iii) Dissolved oxygen deficiency in the balancing tank was found to be a major factor in hydrogen sulphide formation. A number of possible systems were examined, including floating aerators and submerged air injectors, but because of the disturbance effect and the need to ensure adequate sludge settlement, the final decision was to use direct oxygen injection creating micro-bubbles which are rapidly dissolved and dissolved oxygen can now be maintained consistently in solution throughout the tank. This move was rendered all the more effective following the 50% reduction of capacity of the balancing tank; this decreased the liquid residence time and removed the risk of oxygen depletion. A dissolved oxygen sensor in the balancing tank discharge outlet controls dissolved oxygen between 20% and 50% saturation, switching off pump and oxygen injection when dissolved oxygen levels are satisfactory, thereby eliminating oxygen wastage. Up to 3½ tonnes of liquid oxygen at a cost of £300 ($690) are used weekly.

(iv) A further factor affecting the rate of oxygen consumption is the pH in the balancing tank. Levels below pH7 favour bacterial and yeast activity, resulting in rapid utilisation of any dissolved oxygen present. This in turn accentuates production of acidic by-products and a chain reaction ensues involving more and more bacterial and yeast activity generating a further lowering of pH and oxygen levels. As a consequence, pH adjustment by caustic soda addition at the balancing tank inlet was installed, and a pH of 9.0 ± 0.5 is maintained at the balancing tank discharge.

v) The final point is hardly indicated in the table but is a curious indication of the side benefits of integration possible in resource re-cycle. Because the brewery effluent was deficient in nitrogen for the development of purifying bacteria, ammonia had been added - being brought in for this purpose. The Cheshire County Council drew attention to the fact that nitrogen-containing waste from a nearby factory was being disposed of as a waste. Could there be a putting of heads together?

In the event the fertilizer was used as the nutrient supply and the final kill of the odour problem appeared. The number of complaints fell off to the present zero.

The action of the fertilizer was investigated by Mr. Adams. The use of the scrap fertilizer did two things; it introduced nitrate which may be expected to reduce anaerobicity and also traces of cobalt and nickel ion were present. Trials showed the metal ions were responsible for the odour reduction - and before worries of metal accumulation arise let us mention they were present in the parts per BILLION range not the usual parts per MILLION! Their effect is shown in terms of the gas chromatagraphs, in Fig. 2, no other quantitative means being available, but it is almost certain that the reduction in the area of the chromatograms will be reflected in the odour evolution and certain that in practice the smell is knocked on the head.

Thus then runs the case - a successful one illustrating the cost and effort required to solve an odour problem.

A final example is perhaps not strictly a case history but points of interest arising from our own work at Bradford on the odours arising from spreading sewage onto agricultural land.

Initially it should be stressed that the work is in terms of strength and not character of odour. The strength is measured by the dilutions technique giving the number of times an odorous sample requires dilution with clean air to achieve the smell threshold - it is the number of times by which the odour concentration exceeds the threshold concentration. Typically an odorous source will have a strength of 1000 to 1,000,000 Dilutions. What then are the odour strengths when sewage sludge is distributed on agricultural land as a method of disposal or re-cycle?

Results two metres above and downwind of a static sludge tank are in the range 5 to 200 Dilutions. Agitation such as pumping or aeration can increase this to 3,000 to 50,000 Dilutions depending on the vigour of the activity. It would thus be expected that spreading onto land by means varying from a simple trickle to air-gun distribution would cause a similar increase. This we have fortunately not found, the 'during spreading' smell is roughly double the 'after spreading' smell. Typically these later fall in the same range as the quiescent works tank, 50-200 Dilutions. The samples of ambient air used in these tests were taken over about 10 minutes, naturally pockets of air carried much stronger whiffs and crude instantaneous samples simply taken by opening a plastic bag when the 'whiff' was passing showed increases by a factor of two, much greater increases are certain to occur.

The odour strengths vary considerably from sludge to sludge, with weather and with time distance. The detailed results are voluminous, the following points of interest are drawn from them.

Roughly speaking in average weather, that is to say neither persistent rain nor sunshine the smell strength is halved in 50-100 metres. Thus a 100 Dilutions at a point will become less than 5, a rough guess of a complainable level, at 250-500 metres.

An alternative examination is shown in Figure 3 where the travel of smell from a 50-yard diameter spread area, for four wind speeds. Naturally all these tests could not be made on the same day under the same conditions but the general effect has very frequently been noted. The smell can be detected at increasing distances and narrowing angles with increasing wind speed - at 200 metres at 3.5 m.p.h. wind speed and more than 1000 metres at 9 m.p.h. An interesting feature for students of atmospheric dispersion theory is the increase of distance with wind speed.

The length of time for which the smell persisted was variable in the field, at least seven days unless there was strong rain or sunshine. A field effect verified in the laboratory in more detailed tests is the development of two peaks in strength with time. A typical result is shown in Fig. 4 exampling the effect which has shown up time after time. It is not easy to visualise how other than extended storage at the works before taking out onto the land could avoid the problem.

We have also examined the effects of additives which if mixed with the sludge before spreading may reduce or eliminate the problem. These may be classified:-

1) Smell destroyers which by chemical action chemically change the odorous molecules or smell-producing reactions. Mostly these are oxidising agents.

2) Masking agents.

3) Counteractants.

Much emphasis is placed on the distinction between masking agents and true counteractants but the real difference is not clear. Taking the philosophy of manufacturers I look upon it in terms of an analogy: a masking agent will overpower and change the 'olfactory appearance' much as the masks we use for Fancy Dress Balls change the visual appearance. However, if as is claimed, counteractants render the smell non-detectable they would turn one into the Invisible Man.

On this basis, addition of a counteractant in increasing amounts would reduce the odour strength to zero and thereafter increase by virtue of excess - generally somewhat odorous - of counteractant, much as the dotted line in Fig. 5. Typical results from the twelve counteractants tested are also shown and it would appear that success is doubtful. The one product showing an improving effect did so in one test with results that were not reproduced on other samples of sludge.

Two oxidant products were tried with more successful results - not 100% but appreciable improvement (Fig. 6). Alack the effect dies off after about two days and we're back to Square 1 (Fig. 7).

These are but a few of the many, many results obtained in this project, perhaps they do begin to throw some light on the subject. Certainly we haven't eliminated the smell, some is bound to occur which brings us back to the initial point made in this paper namely when is a smell a nuisance?

Remedial measures

August 1974	Timers for Settling Tank scrappers
November 1974	Increased process control
" "	Grain interceptors commissioned
April 1975	De-odourising sprays installed
" "	Trial by-pass of Primary Settling Tanks
" "	Plastic spray curtains fitted
May 1975	Coarse screens fitted
July 1975	Tower washing with chlorinated water
August 1975	Routine washing of supply mains
October 1975	High pressure water washing
March 1976	Experimental spray nozzles
June 1976	New de-odourising spray system installed
July 1976	Mechanical screening commissioned
September 1976	Flow reversal trials
" "	Spent Grain valve introduced
" "	De-odourising sprays modified
October 1976	Drain survey
November 1976	Mains flushing valve installed
" "	Spent Grain interceptor installed
December 1976	Bi-weekly Mains flushing introduced
" "	Yeast interceptor tank installed
January 1977	Tower core flushed
" "	Stand-by mechanical screen installed
May 1977	Spray nozzles cleaned
" "	Fan assisted deodouriser
June 1977	Tower flow reversal introduced
July 1977	Micro-aids trial
" "	Bottle-washer discharges controlled
" "	Aerator trials
" "	Phosphate nutrient trials
November 1977	Top layer tower renewed
" "	By-pass main renewed
June 1978	Back-pumping trial
September 1978	Re-location of ammonia addition
November 1978	Inlet channel modified
" "	De-odourant system on trial (Discontinued December 1978)
" "	New skirt rails installed
" "	Oxygenation of Settling Tank commenced
January 1979	Tower Air Control baffles introduced

May 1979	Use of HCl instead of H_2SO_4 in water treatment plant
September 1979	Hypochlorite trial
October 1979	Fertilizer product used for nutrient supply
November 1979	Investigation into S compounds
March 1980	Investigation of yeast content
April "	New pH control system
" "	Addition of sulphide suppressant
June "	Automation of oxygenation system

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3. A. E. J. Eggleton. Atm Env 1969, 3, 353.

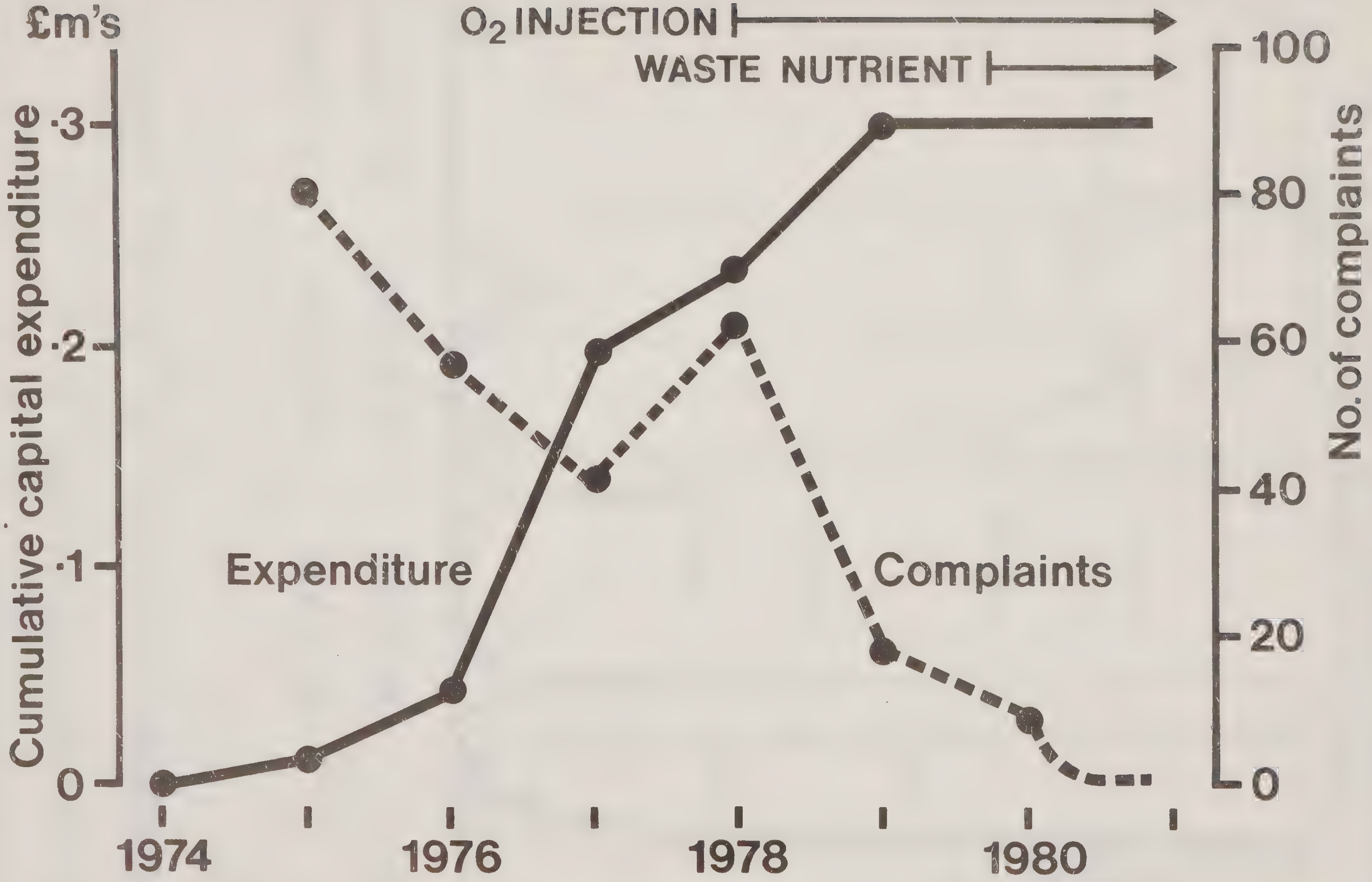


FIG. 1. CAPITAL COSTS OF COMPLAINTS ELIMINATION

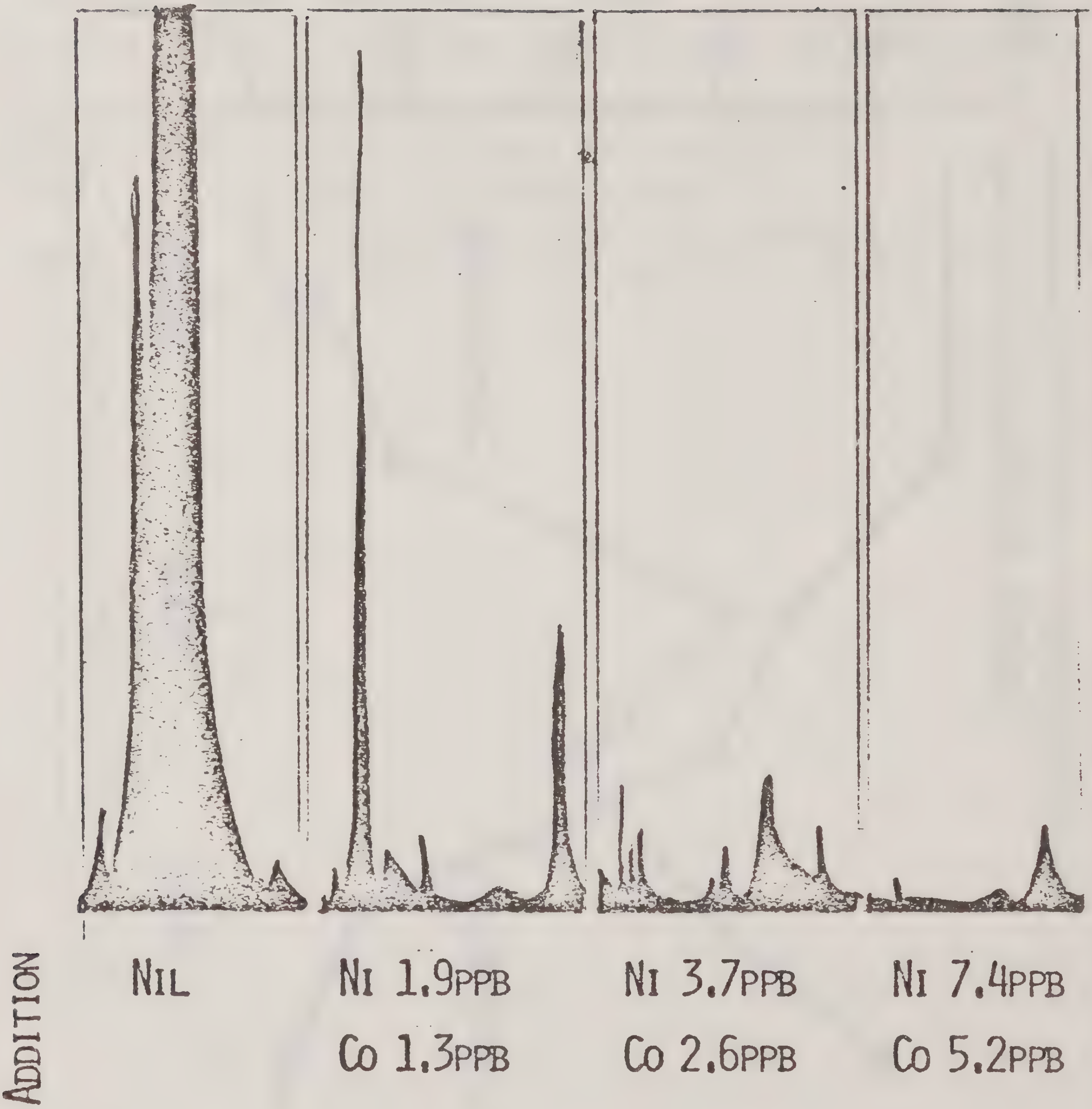
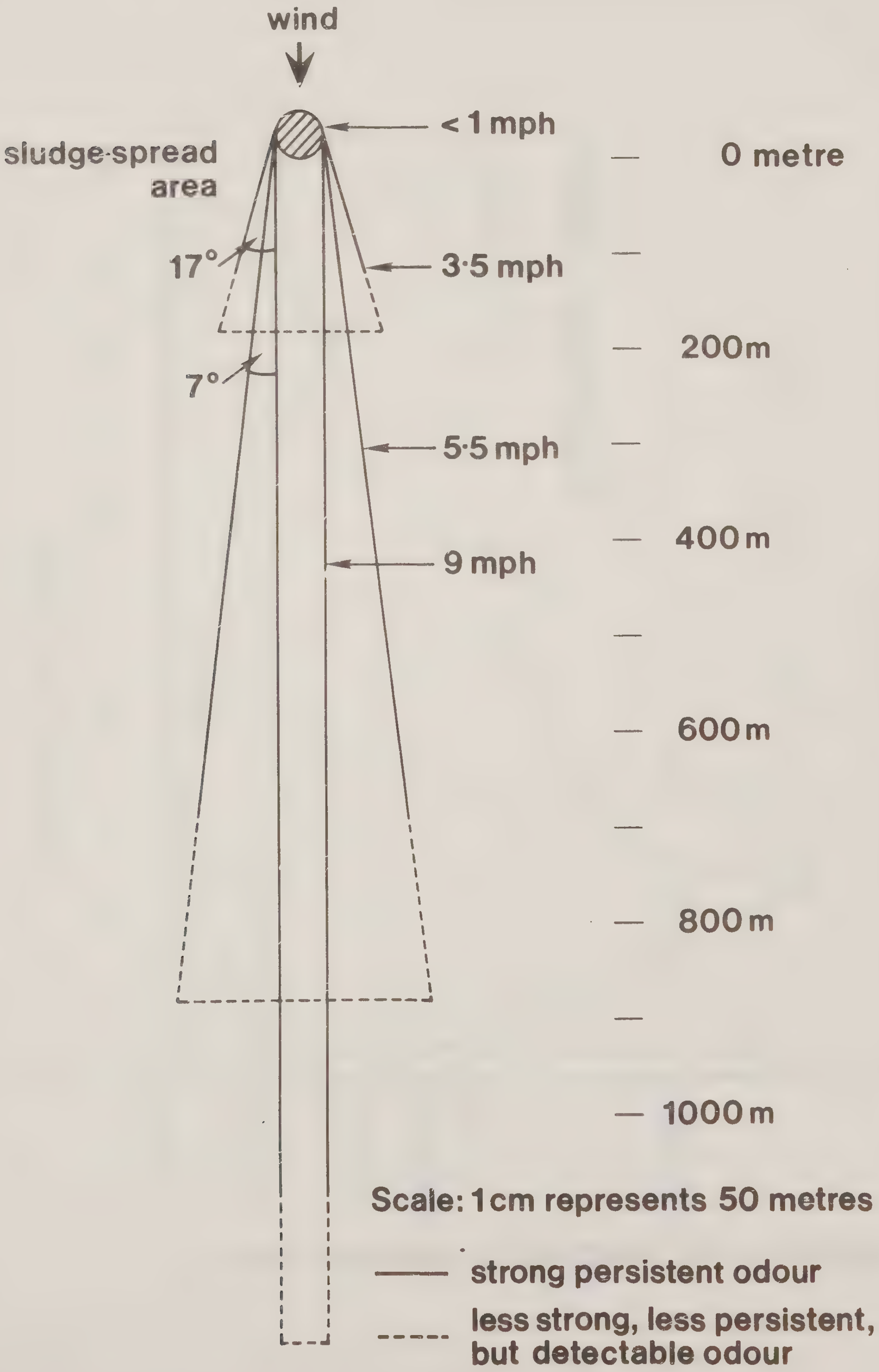


FIG. 2.

CHROMATOGRAPHIC EFFECTS OF Co^{++} & Ni^{++} ADDITIVES

Fig. 3 AREAS OF SMELL OCCURRENCE DOWNWIND FROM A SPREAD SOURCE IN DIFFERENT WIND SPEEDS



Scale: 1 cm represents 50 metres

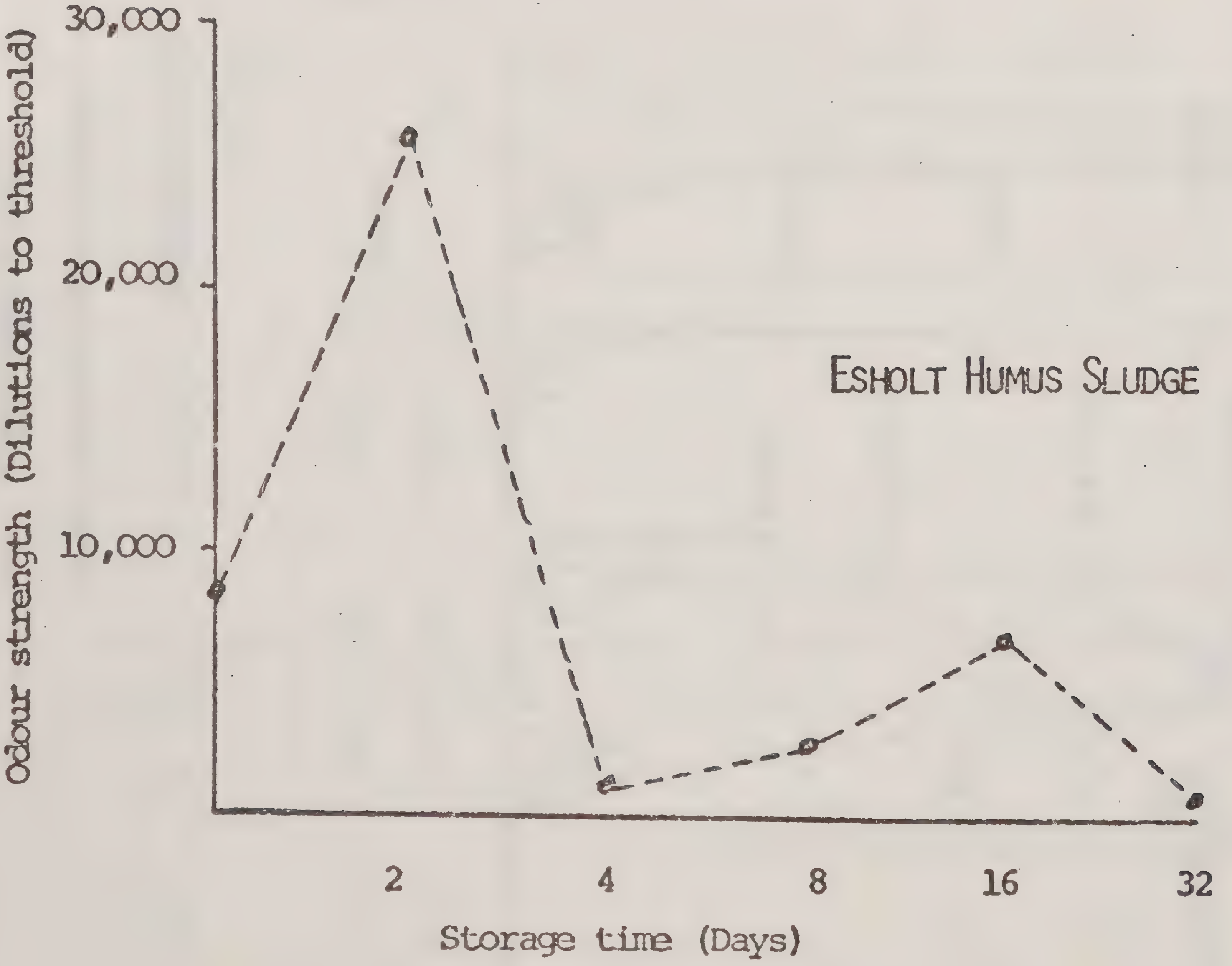


Fig. 4. ODOUR STRENGTH OF ESHOLT HUMUS SLUDGE STORED AT 20°C.

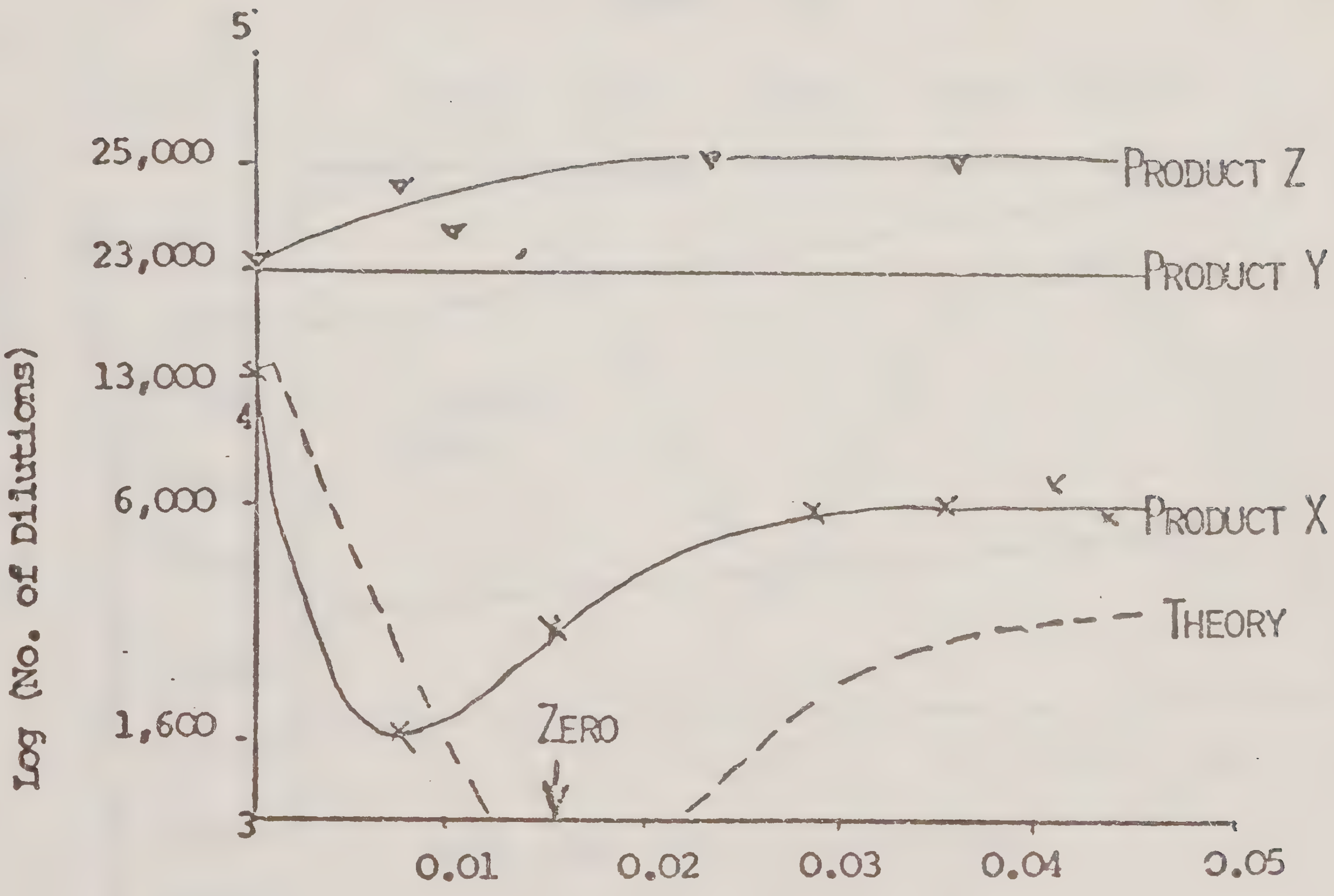


FIG. 5. DOSAGE COUNTERACTANT ml/1 (parts per thousand)

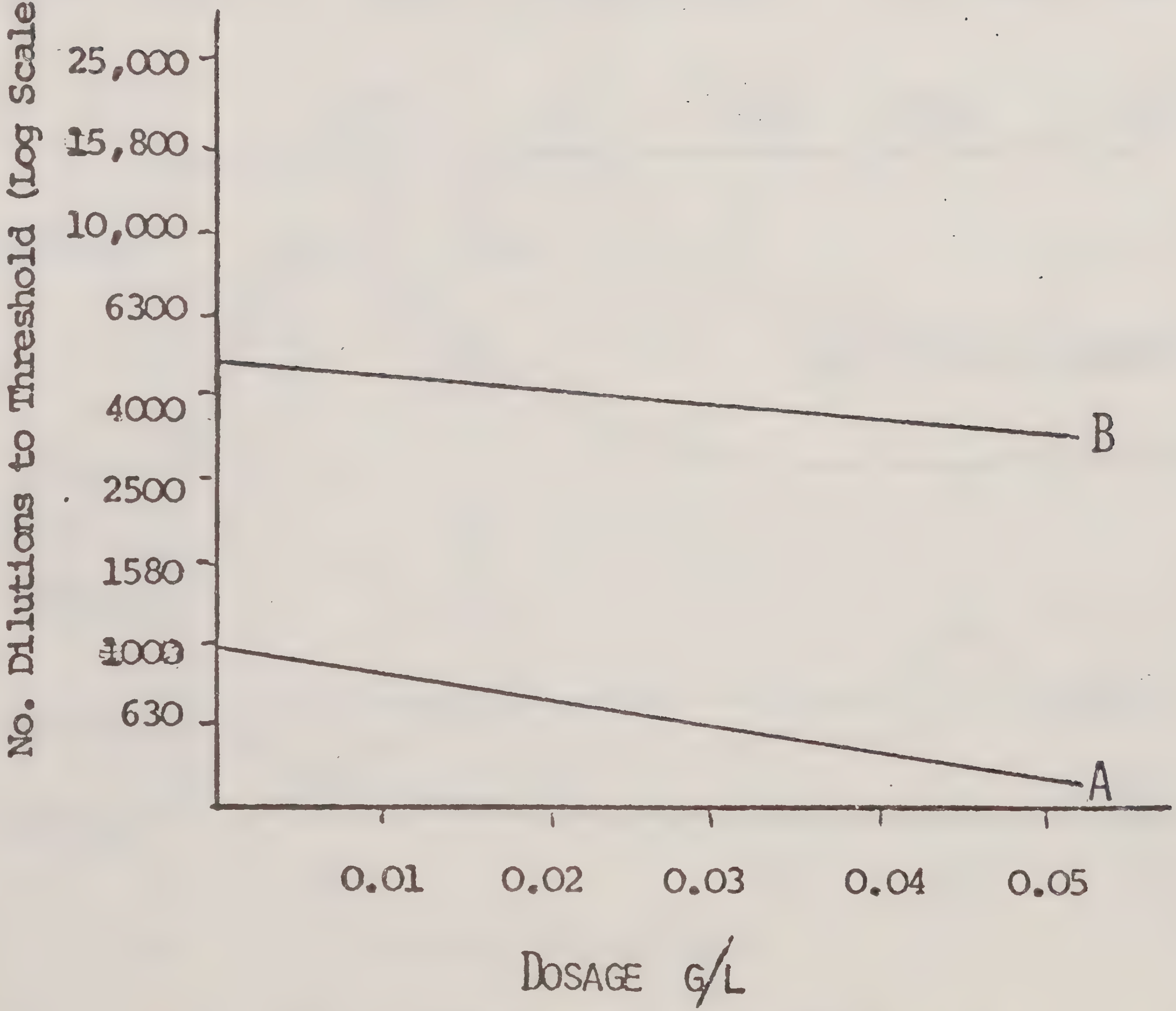


FIG. 6. EFFECTS OF OXIDANTS A & B

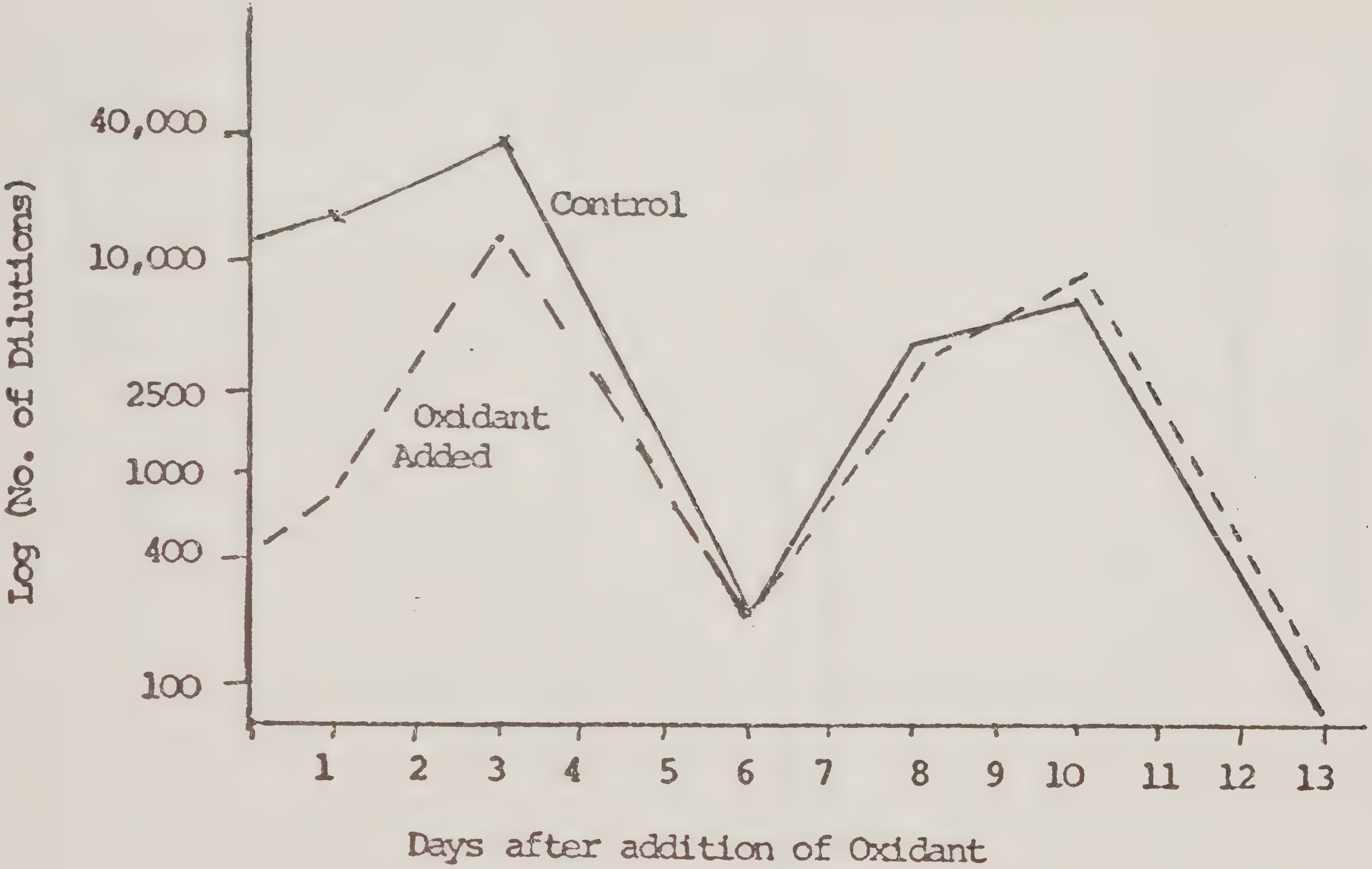


FIG. 7. THE EFFECT OF OXIDANTS WITH TIME

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INCINERATION OF TOXIC AND DANGEROUS WASTES - Practical aspects of disposals by local authorities and industry

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INTRODUCTION

It is well accepted that hazardous chemicals produce hazardous wastes and that there is a need to dispose of them responsibly. It is usually therefore the means of disposal which is the focal point of discussion for each method of disposal has both supporters and critics and each has its place in the league table of costs. Incineration is one of them: it is expensive and it has limitations for it can only deal with organic or partially organic substances. Expensive or not, for many years oil and petro-chemical companies have installed incineration facilities on their manufacturing sites. Why have they done this? Certainly not because it is the most economical method of disposal but perhaps amongst a number of factors which may have influenced their original thinking was a recognition that the problems of disposal would increase with the proliferation of chemical products and that other alternatives would not in the longer term be either available or acceptable. Much has happened in recent times to support the action which these pioneer companies took and since the early 1950's and despite rising costs there has been in the industrialised countries a steady increase in the number of incinerators installed for the disposal of hazardous wastes. The Key Report (1) recommended the increased use of incineration in the disposal of such wastes and since the DPWA 1971 there has been a consequential development: the waste disposal complex offering combined chemical treatment and incineration facilities has become a reality but it has not as yet found unqualified acceptance as an economical means of disposal. This is not just a U.K. problem - few people anywhere, it seems either want to pay to dispose of difficult wastes or to have a disposal facility for a neighbour to enable some others to do so.

CURRENT FACILITIES

Excluding factory installations there are presently not more than 12 sites in Great Britain capable of incinerating hazardous materials. The combined capacity of these plant is in the region of 200,000 tons per annum of which in excess of 50,000 tons is still underutilised.(2) These are operated by private waste management companies and only at three sites, which are all owned by one company, are there facilities for incinerating drummed and solid wastes as well as liquids and sludges. At the moment the quantities of hazardous wastes disposed of by the public sector is negligibly small but will this always be the case?

INCINERABLE WASTES - SOME PROBLEM AREAS

LIQUIDS

Many liquid wastes do not present problems and can safely be disposed of in any standard combustion chamber using a conventional burner. It is those which contain (a) inorganic salts (b) halogen compounds or (c) sulphur compounds which give rise to problems. Those in category (a) produce, on combustion, the metal oxide, the most common found in practice being sodium. The oxide is usually in very finely divided form and requires a high energy scrubber to remove it from the gas stream. The halogen ions most commonly found in category (b) liquid organic wastes are chlorine and fluorine: these are usually fed into the incinerator as chlorinated or fluorinated hydrocarbons. They are relatively insoluble in water and must be converted into the halogen acids by the addition of hydrogen from a hydrocarbon support fuel (either oil or natural gas). The sulphur compounds in category (c) are not so prevalent and the complete combustion of these wastes with a minimum of excess air to present SO_3 formation will enable the SO_2 to be handled by a scrubber utilising a caustic solution.

SOLIDS

As with liquids there is a vast range of composite solid wastes, an increasing proportion of which derives from petro chemical products. The potential hazard from compounds generated on the combustion of plastics depends on the atomic composition of the polymer, the additives used in formulating the plastic and the conditions under which it is burned. Plastics such as polyurethane can be dangerous when decomposed under open burning conditions and those treated with fire retardent additives such as bromine, nitrogen, phosphorous and antimony also give rise to problems including that of incinerator corrosion. The following notes on representative plastic materials will indicate why problems can arise when they are burned.

(a) POLYURETHANE

There is evidence that the combustion of this material may result in a wide variety of hydrocarbon and nitrogen containing products in the gases as well as carbon monoxide and cyanide. Neither of these latter would be expected to form in significant quantities during high temperature incineration but substantial amounts could be generated during open burning or an accidental fire. Carbon monoxide affects the ability of the blood to carry oxygen and cyanide disrupts the cells ability to use oxygen and there is therefore a biological synergism between the two compounds making their presence in combination particularly hazardous.

(b) POLYVINYL CHLORIDE

This polymer can be a considerable nuisance particularly in view of its high chlorine content. Chemical composition:- 56.73% chlorine, 38.44% carbon, 4.84% hydrogen. It has a low boiling point ($< 130^{\circ}C$) and is used in a wide variety of products which include sheeting and floor tiles. Combustion products vary considerably with the materials some of which contain considerable amounts of fillers such as asbestos, calcium carbonate and silica. In the case of floor tiles fillers account for 70% of the product.

(c) POLYSTYRENE

This material is an aromatic polymer made up of 92.3% carbon and 7.77% hydrogen. On heating it has a one step degradation at just below $300^{\circ}C$. Because of its chemical composition soot generation is a problem and since a carbon particle, once formed from an "aerosol" droplet, requires a temperature of $800^{\circ}C$ before it will burn, high temperature conditions, adequate residence time and good mixing are essential to avoid smoke emissions.

These three plastic materials are often present in mixtures of solid wastes for incineration. Mixture has a very important bearing on the design and operation of incinerators since it is the interaction of the chemical consituents both in the gaseous phase and in the fire bed which will determine the problems to be dealt with in the furnace and in the gas washer. They must be able to handle widely ranging mixtures since the composition of each charge presents wastes in differing proportions and hence a varying air/fuel ratio requirement for complete combustion. Mechanical feeding systems, or rather the lack of them have often been blamed for the widely varying furnace temperature and whilst undoubtedly there are problems to be overcome in this area the composition of each charge fed to the furnace has its effect on conditions within it. Even in liquids it is well recognised that chemical compatability is sometimes difficult to establish particularly when slow reaction polymerisation takes place in storage and similarly it is reasonable to assume that combustion inhibitors or accelerators will have their effect on combustion and combustion products, both in the gas stream and in the char bed. Not enough is yet known in this area of combustion practice but it is one in which field and laboratory research work is being carried out. This work includes differential thermal analysis of plastic and other compounds to determine the temperatures at which chemical and physical changes take place coupled with the use of gas chromatography and infra red techniques to establish the compounds present in the combustion gases.(3) In the case of PVC, 52 compounds have been identified (even wood has 19) and it is the study of the interaction of these compounds at temperature which will provide, it is felt, a most useful basis for the prediction of the burning characteristics and the toxicity of combustion products.

It must be remembered that where chlorinated materials are involved there is, for both solids and liquids, a statutory limit of 460 mg/m^3 for HC1 and the presumptive limit of 10 ppm for the total chlorinated hydrocarbon content in the stack emissions - limits which in most cases can only be met by the mixing or blending of chlorinated and non chlorinated wastes before firing. Additionally if on Inspectorate approved plants P.C.B.'s (Polychlorinated Biphenyls) are burned, which are slow to oxidise, the incinerator temperature must be maintained at 1100°C and the mean residence time must be at least 2 seconds with 3% excess oxygen in the gases before the scrubber.

DRUMMED WASTES

Drum burning of wastes can present problems particularly if the contents polymerise at temperature or if the surface carbonises rapidly. Burning can only be from the exposed surface of the waste and careful positioning of the drum chamber burner or burners is essential in order to vary the burn out conditions for differing materials. For this reason high throughputs from a drum burning unit are not usual and considerable handling costs can be involved. Refractory topped trolleys have been used very successfully on a number of installations in the U.K. and drum tippers have been used both in Europe and the United States. Conveyors have also been adapted to ease the handling problems.

FLEXIBILITY IN DESIGN

It has been mentioned that of the dozen or so commercial high temperature incinerators in the U.K. only three, so far as is known, are capable of burning a mixture of solid and liquid wastes. Combination plants are of course more expensive to install but in continental Europe and the United States both chemical companies and commercial waste disposal contractors have opted for them and more of the same type are presently being built. Two designs have found favour, namely the rotary kiln and the multiple chamber unit: the reason for this is that they can each provide flexibility for firing a wide range of wastes in varying proportions. In contrast a 'liquids only' plant can seldom be adapted to fire anything else since it does not have the necessary furnace volume. As far as the multiple chamber furnace is concerned two large units designed to fire mainly liquids were from necessity successfully modified to burn a predominance of solids without any major alterations to the plant.(4) Only the rotary kiln can approach this degree of versatility. The two designs are similar in that they have one long firing chamber. In the case of the rotary kiln it is circular and continuous whilst in the fixed type it is rectangular and continuous with interconnected chambers. The multiple chamber furnace has an advantage in that temperatures can be adjusted via burners and fan air from chamber to chamber along its length. Extended residence times of 2/3 seconds are readily available with this system but in the case of the rotary kiln these can only be obtained by the fitting of a secondary combustion chamber beyond the rotating section.

Typical layouts of Rotary and Multi purpose incinerators are shown in Figs(i) and (ii). In recent years there has been considerable development taking place in the 'packaging' of plant in order to reduce site work and hence cost. The extent to which this can be done is of course a function of the throughput of the unit but capacities of a ton an hour have been successfully shipped overseas in semi packaged form.

With quantities of waste established with a reasonable degree of accuracy the table below summarises the factors which influence a complete design. The incinerator is only part of the disposal process which comprises handling, storage, feeding, gas cleaning and ash disposal; too often to the detriment of the project, it is considered in isolation.

The following points which incorporate the latest draft recommendations of the Alkali and Clean Air Inspectorate for plants within their jurisdiction relate to these procedures:

1. Feed Rate: For installations handling a wide range of chemical wastes a detailed programme should be kept specifying the appropriate feed rate and operating conditions for each batch of waste to be incinerated.

Category	Analysis	Handling & combustion	Construction materials	Emission control
Solids	Calorific value	Waste transfer	Refractories	Afterburners
Semisolids	Chemical composition	Blending	Insulation	Fume destruction
Sludges	Quantity	Feeding	Casing	Trapping incombustibles
Liquids	Physical characteristics	Firing		Stack design
Gases		Furnace volume		Ash removal
		Air, temperature time		Washwater
		Instrumentation		
		Overall control		

2. Suitability of Wastes for Incineration: Account must be taken of the chemical and physical factors, so as properly to establish the appropriate residence time, combustion chamber temperatures, and the likely chemical constituents of gaseous and particulate emissions from the furnace.

3. Support Fuel: An adequate supply of support fuel must be available for bringing the combustion chamber or chambers to the minimum temperatures required for complete combustion of the wastes being handled and for maintaining them within controlled limits whilst the plant is firing.

4. Temperature Recorders: Each section of incinerator should be fitted with temperature recorders and the final combustion chamber (afterburning section) equipped with an audio/visual alarm for low temperature conditions.

5. Monitoring of Oxygen: An instrument for the continuous monitoring and recording of oxygen in the flue gas should be installed where practicable and preferably the sampling point should be sites immediately downstream of the final combustion chamber and before any arrestment plant.

FLUE GAS TREATMENT

1. Design and Method of Operating: Flue gas treatment plant must take into account the type and quantity of wastes to be incinerated. Plant handling a wide variety of wastes will be required by the Inspectorate to have treatment systems to deal with both gaseous and particulate matter. Typical equipment is shown diagramatically in Appendix A. In most cases a high efficiency scrubbing system will be required and in special circumstances flue gas reheating may now be necessary to reduce or eliminate the chimney vapour plume which results from its use.

2. Monitoring of Washing Liquid: Where scrubbing plant is used the wash water circulation should be monitored for pH and flow to give continuous indication of operating conditions.

3. Variable Pressure Drop Scrubbing Plant: Where variable pressure drop scrubbing plant is fitted there should be continuous recording of the differential pressure across the variable section since this has a considerable effect upon efficiency of operation.

SAMPLING AND MEASUREMENT OF EMISSIONS

Instruments for continuous monitoring of emissions may now be required by the Inspectorate on both new and existing plant if there is evidence of inadequate emission control. Continuous sampling of particulate matter for subsequent analysis may also be regarded as necessary when an incinerator is handling a wide variety of wastes.

CHIMNEY

1. Efflux Velocity: Chimneys are now normally designed for an efflux velocity of notless than 15 m/sec. at full load operation. Care must be taken to avoid generating positive pressure zones within chimneys unless the chimney walls are impervious or lined. Where wet arrestment methods are used, the linear velocity within the chimney

must not exceed 9 m/sec to avoid entrainment of droplets from the chimney surface into the gas stream.

2. Natural Draught: Where only natural draught is available, efflux velocities shall now be the maximum practicable in the particular circumstances and are a matter for consultation with the Inspectorate.

3. Insulation: All new chimneys must now be designed and insulated to minimise the cooling of waste gases and condensation on internal surfaces. This is particularly important for acid gases.

GENERAL OPERATIONS

1. Best Practicable Means: This now applies not only to the control of emissions but also to the efficient maintenance, proper use of equipment, and adequate supervision of the burning process. Planned maintenance shall now be incorporated in operational procedures to the maximum extent and an adequate supply of essential spares must be held. Duplicate equipment should now be installed whenever practicable and necessary to allow continuity of operations whilst minimising emissions to atmosphere.

2. Malfunctions or Breakdowns: Whenever abnormal emissions occur which might significantly affect the environment, the Local Authority and the Inspectorate must be informed immediately. The plant must not continue to operate with substandard emissions for extended periods without first having consulted the inspector.

3. Staff Training: Staff at all levels must receive proper training and instruction in their duties relating to control of the process and emissions to atmosphere. Particular emphasis should be given to training for start-up, shut-down and abnormal conditions.

4. Housekeeping: A high standard of housekeeping must be maintained with particular attention being given to chemical waste storage areas.

MAINTENANCE PROBLEMS

Rarely does an incinerator designed and installed for a particular purpose continue to serve that purpose for any extended period of time. In a factory either the product changes and hence the waste to be fired or the quantities of wastes vary in their anticipated proportions. In a disposal complex the wastes available for firing are even less predictable. It has to be recognised by an supplier of incineration equipment that this is a fact of life but the problem is how to provide the best all round product at an economical, not to say competitive, price. It is often difficult to convince a purchaser that there is a minimum material quality specification for a furnace able to stand up to the rigours of day to day use and sometimes abuse and that you only get what you pay for. In the United States it is, according to reports, affecting the efficiency of some projects in the public sector. In a recent interview with the Editor of a well-known magazine an engineer commented "when you compete for a Municipal contract throw away your degree .... and come up with the lowest bid. Know-how, capabilities, experience, future reliability, alternative technical options and cost effectiveness don't really cut any ice!!" This may be an exaggerated viewpoint and it is not to suggest that as a country we are thinking this way too but, in times of stringency, cost is important and the temptation to save in capital cost at the expense of higher maintenance and plant down-time must surely hover in the background of many a presentation for approval of capital expenditure. To be reliable in service an incinerator must be rugged in construction for its 'internals' work in a harsh environment at both ends of the temperature scale - high in the furnace and low after the gas washer.

INCINERATOR CORROSION

Taking the furnace area as a first consideration: it must be lined with refractory material chosen against a background of the known contaminants. It must be one which does not melt at operating temperatures, be able to withstand thermal cycling without racking and have low prosity coupled with a high resistance to attack by chemical slags. The presence of alkali metals in the molten state gives rise to spalling or flaking off by a process of penetration and freezing, and this can lead to a rapid reduction in wall thickness. HC1 will readily combine with alkali metals to form salts and when a furnace is pressurised it will, as a gas, readily penetrate linings and condense out on the inside of furnace casings. In bricked chambers jointing materials often allow easier penetration and for this reason chemically bonded refractories of the moulded or ramming types are now generally used. An exception is rotary kilns where abrasion resistance is of considerable importance and brick must be used. Lack of turbulence within the furnace area can result in stratification of the gas stream and generate conditions for partial combustion in a reducing atmosphere. Under these circumstances CO and H_2S can be produced which in combination with HCl are known to give rise to corrosion at the back end of the plant on any water cooled surfaces when sticky ash deposits are present.

SCRUBBER CORROSION

The presence of chlorides at a low pH limits the use of stainless steels and 316 stainless has not proved at all successful due to stress corrosion pitting and cracking. Mild steel venturis lined with glass reinforced polyester have been proved satisfactory. Titanium has proved an attractive if costly material for scrubbers handling chlorides and sulphates with a pH of 2-3. It has performed well in a PVC incinerator scrubber and is also said to be an attractive economic alternative to Inconel 625 and Hastolly C-276 which have a similar resistance. Non metallics are considered more suitable for the secondary mist eleminator section.(5)

One of the problems in the selection of materials is that apart from the acid content itself the corrosiveness of the scrubber water becomes greater because of dealkinisation whilst particulates in the water accelerate corrosion as does, in some areas, water velocities.

In both quench chambers and scrubbers close control of neutralisation is essential. Even in the stack where there are only small quantities of acid present there can be problems with the chimney acting as a reflux condenser concentrating acids in the process. In such cases multi-coated epoxy resin coatings on carefully prepared metal surfaces have been reasonably successful.

There is no question but that if corrosive and abrasive constituents are present in the system then maintenance costs will be proportional to the quantities which are burned. On a rotary kiln mixed waste plant burning solid, liquid and rummed wastes including chlorinated residues the average annual maintenance cost is reported as between 5 and 6% of the capital cost.(6) It operates under arduous conditions and the average plant would have lower costs than these.

The corollary is that an accurate survey of the wastes to be burned followed by a careful selection of materials of construction for each item of equipment will reduce maintenance costs provided that the plant is operated within its design parameters. There will always be a heavy price to pay if it is not.

HEAT RECOVERY

In almost any incineration system heat recovery is possible but there are risks involved.

Generally speaking the corrosive nature of waste gases in toxic waste incinerator plants make them unsuitable for waste heat recovery. Even in relatively straightforward applications corrosion of heater surfaces can be a problem and has been found to be accelerated by the presence of sodium, potassium, chlorine, zinc and lead. High temperature corrosion has been prevalent with carbon steels corroding at the rate of 50 mils/month at 510°C whilst a simulation of wet deposit conditions resulted in stress corrosion cracking of 304, 310 and 316L stainless. (5) Acid gases all have dew points which must be rigidly observed if waste heat recovery is used and in terms of particulates if these are dry then they can be removed by conventional means. Only one operational mistake is necessary to cause severe corrosion and possible failure of the heat recovery system. Heat recovery is best applied to installations where clean burning solid or liquid wastes are available.

THE FUTURE

Combustion engineers everywhere and not least here in the U.K. are looking very closely at the basic research work which is being undertaken in the field of thermal decomposition. Combination processes of pyrolysis and after-burning have already shown that by the addition of inexpensive reactive compounds to wastes and allowing them to combine elements such as chlorine and sulphur it is possible to form non vapourising solid compounds of these substances so allowing them to be retained in the ash. Residence times for the complete combination of a wide range of chemical compounds with excess oxygen are also being established in the laboratory. All these are positive steps towards a better understanding of the effect of wastes burning in combination and will be the means of translating theory into practice. Incineration remains neither a science nor an art but a combination of the two and empirical data is often more reliable than theoretical calculations. This is no reflection on theoretical data but within the furnace mixing, temperature and residence time are so interrelated that computerisation is impossible. Of these three factors it is mixing of air, fuel, combustion products and newly fired waste materials which is not finite being empirically different for each type of incinerator. It will remain the 'x' factor for perhaps some time to come with scientists, combustion engineers and fuel technologists all striving for improvement in thermal destruction techniques.

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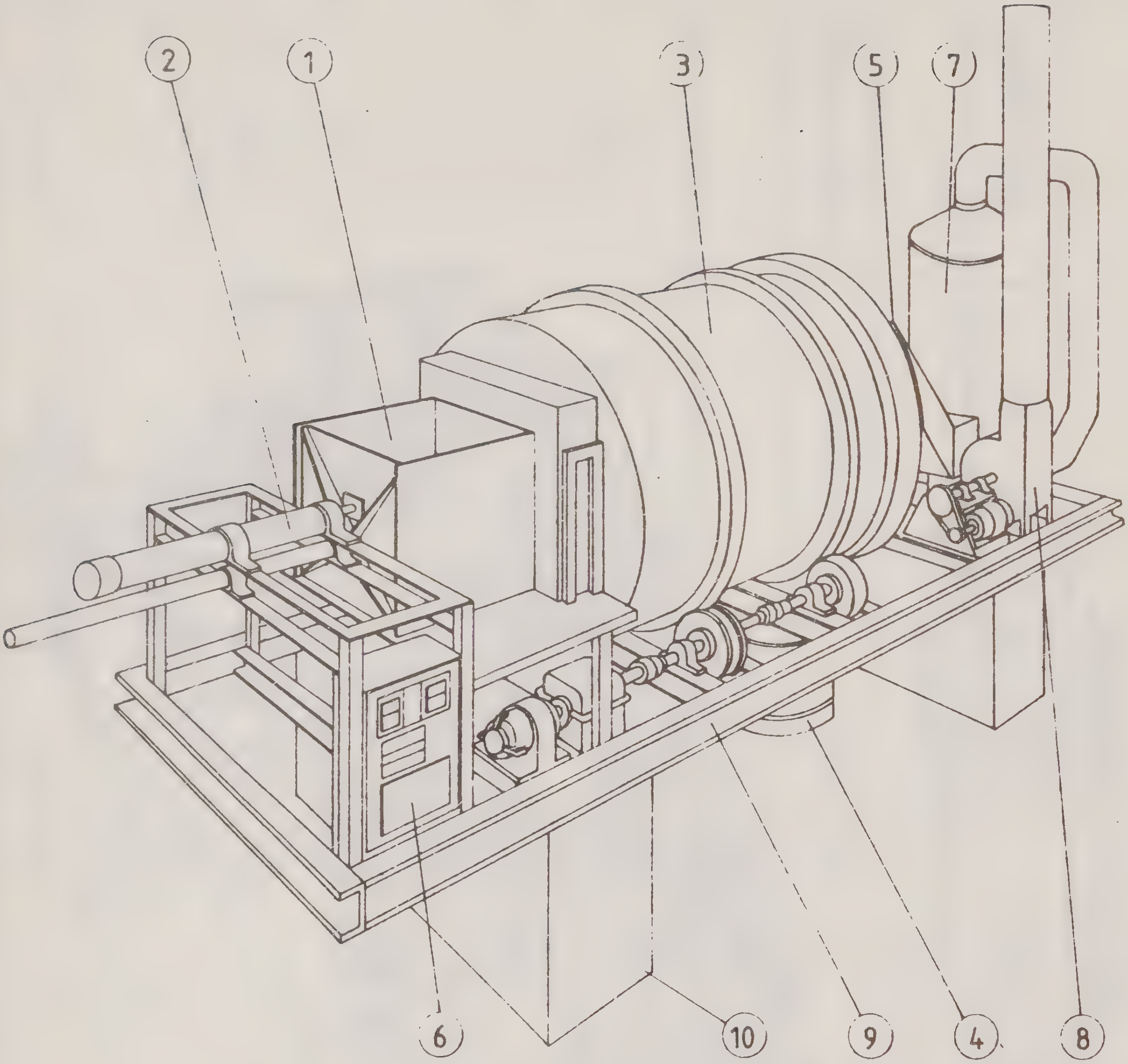


① WASTE BIN
② AUTO CYCLE FEEDER SYSTEM
③ ROTATING CYLINDER
④ ASH BIN
⑤ AUTO CONTROL BURNER PACKAGE
⑥ SELF COMPENSATING INSTRUMENT CONTROLS
⑦ SCRUBBER
⑧ EXHAUST FAN AND STACK
⑨ SUPPORT FRAME
⑩ SUPPORT PIERS

Figure (i)

1. Sludge/residues burners
2. Ignition burners for sludge/residues furnace
3. Combustion air fans for sludge/residues furnace
4. Sludge/residues furnace
5. Firebar hearth furnace combustion air fan
6. Solid hearth furnace combustion air fan
7. Drum furnace combustion air fan
8. Ignition burner for drum furnace
9. Ashing doors
10. After burner No. 1
11. After burners combustion air fan
12. Cooling air fan
13. Gas washer spray water manifold
14. Gas washer effluent outlet channels
15. Draught regulating damper
16. Standby sludge/residues burner
17. Ignition burners combustion air fan
18. Auxiliary waste oil burner
19. Standby ignition burner combustion air fan for firebar hearth furnace
20. Standby sludge/residues burner combustion air fans for firebar hearth furnace
21. Stack (suitable for two units)

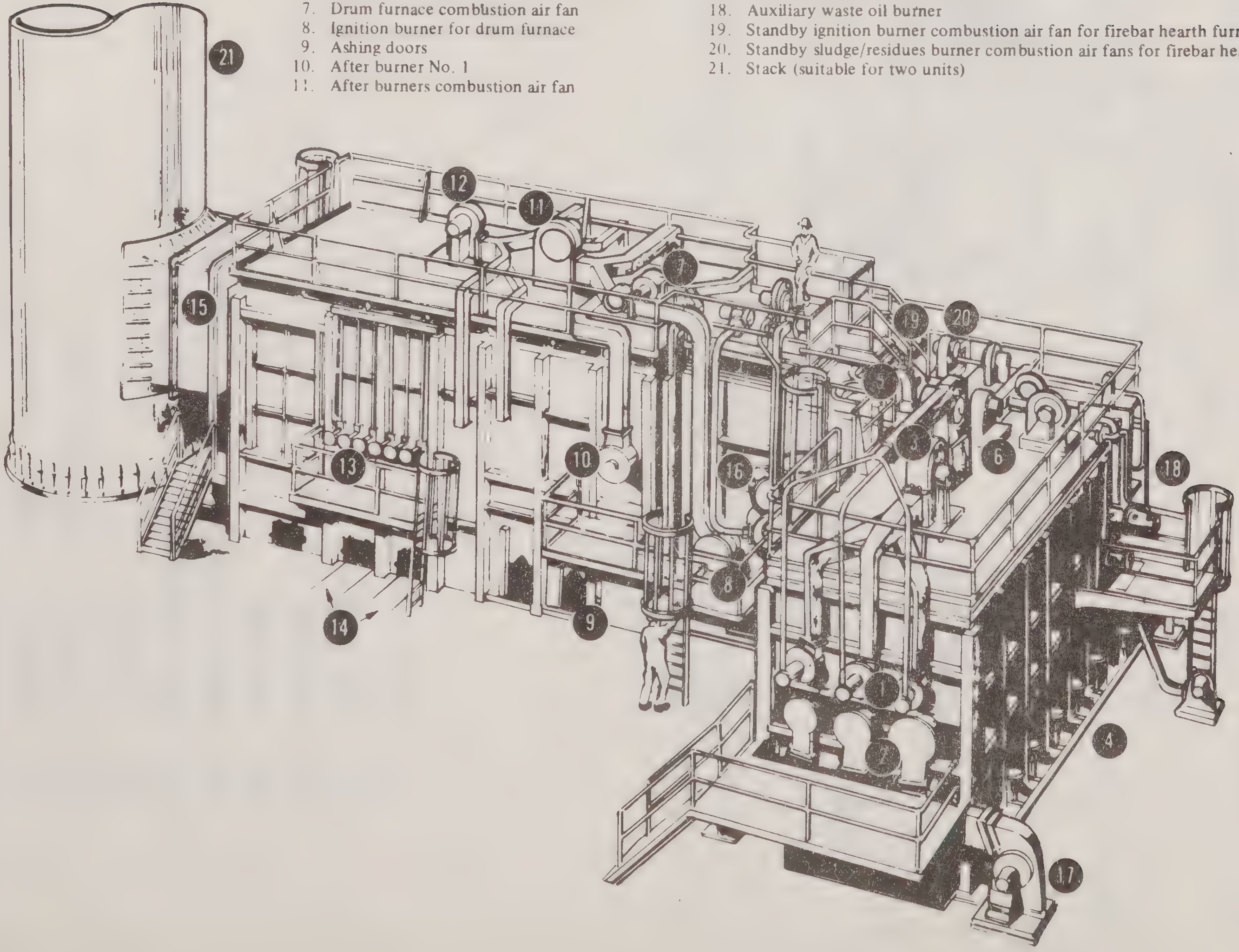
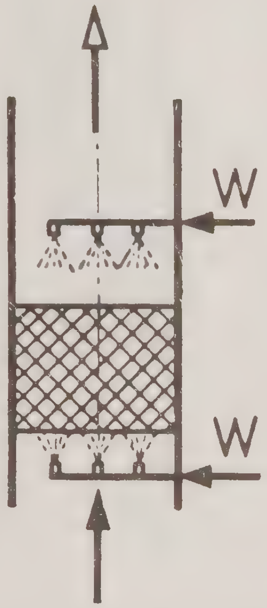
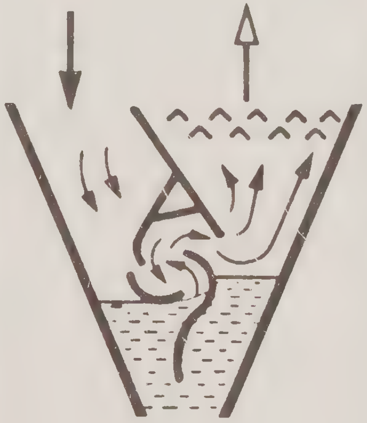
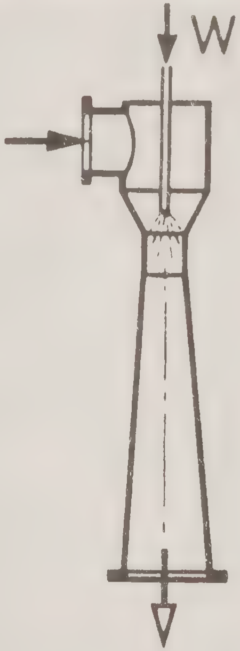
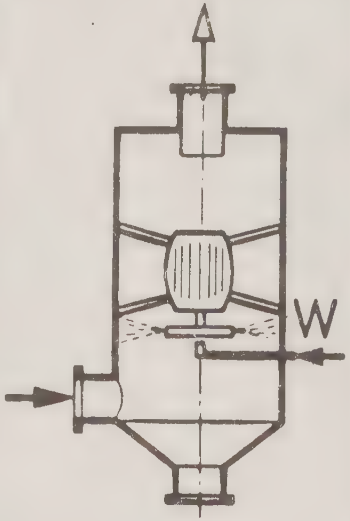
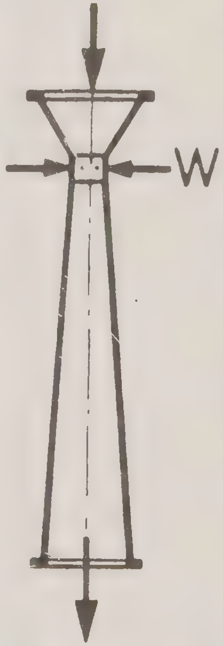


Figure (ii)

wash tower	scrubber	injector	disintegrator	venturi
				
cut size for sp.gr. 2.6				
$>1.1\,\mu$	$0.7-1.0\,\mu$	$0.6-0.9\,\mu$	$0.4-0.6\,\mu$	$<0.01-0.04\,\mu$
pressure drop mm H_2O				
20–200	180–280	–	40 –100	300–2000

WET COLLECTORS

NATIONAL SOCIETY FOR CLEAN AIR

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THE RE-USE OF CONTAMINATED LAND

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1. "Contaminated" is defined, in at least one dictionary, as "made impure or noxious, polluted, tainted." The description "noxious" is similarly defined as "hurtful, corrupting, injurious". In the context of this paper, therefore, consideration is given to the further use of land which has been so affected by man's former activities that it has become actually, or potentially, harmful or injurious, either to human life or plant life, or both. The harm can arise from physical sources, such as collapse of shallow old mine workings, or from chemical factors, such as heavily contaminated land or liquid, including gaseous effects.

2. In view of the many problems which arise from the re-use of contaminated land, it is interesting to examine some of the reasons behind such proposals. Land falls out of use for many reasons. In the case of tipped land, the tip has perhaps reached its final levels and can accept no more waste. Where industry is concerned, changed methods of production, new products, adverse economic circumstances, changes in demand, together with other factors, can all lead to the closure of a particular works or even, over a period, of a whole industry. The manufacture of town gas is just such an example. It might be considered that the present economic climate is remarkably conducive to such industrial closures and it is possible that the production of new areas of contaminated land is rising in proportion to the number of industrial closures. On the other hand, the pressure to re-use contaminated land for industrial development is reduced and some of the potential problems are deferred into the future. On a warning note, however, this will not result in a diminution of the problem, either in complexity or scale. Many contamination problems have potential for extending far into the future and can certainly affect the next generation at least.

2.1 Much of the pressure for re-use arises from factors such as location of the site in relation to existing markets, both for labour and for product disposal, the availability of service infrastructure in terms of sewers, access roads, public utility services and transport facilities, to name but a few. The public investment in such aspects of modern industry is too great to abandon and too expensive to duplicate elsewhere before reaching the end of its economic life. In many cases, too, the existence of the former site, now disused, is a blight on the urban or rural landscape and local authorities are, rightly, keen to see such land re-utilised, particularly when there are tight constraints on the availability of land generally for development in an area or region. The Ministry of Agriculture also insist that the demands for use of agricultural land for development in an area or region. The Ministry of Agriculture also insist that the demands for use of agricultural land for development should be resisted to try to contain the reduction in agricultural land use.

3. Contaminated land can be found in most areas of the country but is perhaps most prevalent in those districts and regions where the industrial revolution created most of the development. Such development is now reaching the end of its productive economic life, or is well beyond it, and the industries which it established are now causing problems by their demise. Parts of such regions are characterised by mineral extraction, both at ground level and by mining, followed by their tipping with waste materials. Many such tips are very old and have no recorded history. Indeed, their very location is frequently unknown until they are discovered in the course of new development. It is in these areas that pressure for new industrial development creates the demands for re-use of contaminated land mentioned before. Even in the countryside, pressure for recreational use or compensational restoration to agriculture on an "environmental exchange" basis leads to the treatment of difficult sites which might otherwise lie unused for many more years.

4. Land can become contaminated by many causes. Although examples are given as follows, these are by no means exhaustive and the variations on some of the themes are almost infinite. Each case, when examined, has its own unique features and this means that it is virtually

impossible to lay down standard methods of treatment for varying types of contaminated land. The problems are consistent only in their inconsistency.

4.1 Former waste disposal landfill sites can be generous providers of problems for the unwary (or even wary) redeveloper. Fools may rush almost literally in to some such sites where natural life even lighter than angels may fear to tread. Stability problems are uniform to such areas, though they can vary from a relatively uniform (low) bearing value to considerable difficulties in differential settlement with consequential effects in strains and stresses on any structure unlucky enough to be built on them. Although there are many examples of development, including structures, having taken place on such sites, many of these are on old domestic waste tips where conditions, at least chemically, have stabilised many years ago. Modern landfill sites are a very different proposition, being constructed very much more quickly with heavy compaction plant, or using baled waste. This type of site has become much more predominant following local government re-organisation and there has not yet been sufficient time for a pattern of behaviour of the waste in such sites to be observed. As one example only, the relatively slow, loose filling of the former smaller sites, allied to the type of domestic waste deposited, allowed time for the generation and dispersal of much of the methane gas generated while the site was being worked. The same applied to leachate from the tip, with its waste polluting characteristics. Now methane generation has reached the stage in some waste disposal sites that serious efforts are being made to collect it and use it for industrial purposes, while leachate can be produced in large and very strong amounts, C.O.D. values of 25,000 to 35,000 being not uncommon for mainly household waste sites.

4.2 Such problems are, of course, compounded when the waste is a mixture including industrial waste, particularly where waste chemicals are concerned. In earlier years there was considerable ignorance of the consequences which could follow when various types of chemical wastes were deposited in close contiguity with each other. Indeed, some authorities would aver that such ignorance (or carelessness) still exists. The main problem here is that many of the chemicals, or their constituents, have a very long life indeed, being persistent and having cumulative effects. Many sites containing such substances are fatal to plant life (phytotoxic) and can also be so to animal and human life. While serious cases have been relatively rare in this country, the Love Canal episode in the United States of America, where serious damage to human health occurred, is by no means an isolated instance on the world stage.

4.3 Not only chemicals can cause problems, of course. A relatively common source of risk is the existence of old tips containing large quantities of asbestos, both white and blue. While these remain undisturbed and covered, they represent little risk, particularly under damp conditions. Their excavation, however, and the possible release of large quantities of airborne particles into the working environment can prove fatal in the relatively middle and long term, particularly to people with an above average exposure to it. Centres of the asbestos industry, such as Calder Valley in West Yorkshire, have disclosed, on occasion, the existence of such old, disused tips. Modern practice of disposal of such materials is still to bury them in landfill sites, but under well controlled conditions, while current legislation ensures that the sites and their operations are well documented.

4.4 Landfill of a different type occurs at old sewage works, now known as water pollution control works. These, when disused, frequently contain large sludge beds in addition to the "hard" building construction at the works themselves. Physical dangers can exist from dangerous ground conditions, with a crust of firmer material overlying soft sludges, or from underground services whose covers have been removed and not replaced. These sites provide difficulties, however, in establishing vegetation following regrading, which can in itself be difficult to achieve satisfactorily. Because of the existence of heavy metals within the sludges, usually zinc, copper, nickel and others in varying proportions, phytotoxic properties can be developed, particularly if the sludges are spread over acid land such as re-contoured colliery spoil tips.

4.5 While tipped land and disused sewage works are generally more usually found in comparatively rural areas, at least until urban sprawl reaches them, disused gas works are commonly an urban hazard or, more correctly, a Pandora's box of hazards. Certainly, once "the lid is lifted" on such sites, a whole range of problems can be exposed. After-use of such sites is invariably extremely expensive, frequently involving the removal of considerable quantities of hostile substances containing toxic metals, phenols, cresols, acid tar wastes, spent oxide, and so on. A very wide range of environmentally hostile substances should be expected to be found. As a bonus to the practitioner in reclaiming such sites, it will be further complicated by the existence of deep and heavy foundations, buried tanks and tar wells and a network of underground services and ducts. While such sites can be developed for industrial purposes, the redevelopment must be carefully tailored to site constraints if excessive expenditure is not to be incurred.

4.6 Similar material and foundation problems can also be met when dealing with disused coal mines. The former mine owners built their collieries as if they were intended to last forever and foundations were constructed accordingly. In such cases, the problems are mainly physical, related to the existence of old shafts or to shallow old mine workings which can collapse suddenly with catastrophic results to the immediate neighbourhood. Many such workings are completely unknown, no record having been kept of their construction and only a knowledge of the general mining situation in the area can assist in realising that such risks exist. Similar comments apply to old shafts, a known hazard in mining areas.

4.7 Turning to the associated problem of disused coal products works, such as former coking plants, for example, the difficulties here can be both physical and chemical. The usual construction factors apply, but can be compounded by the hazards of contaminated buildings and ground, particularly where the latter is saturated by polluting liquids created by the coke manufacturing process. Where the buildings are still standing, these can be heavily contaminated and there are usually very long runs of pipework insulated by asbestos which will need careful and controlled demolition and disposal. If total site clearance takes place, even though expensive, the difficulties of redevelopment are mitigated.

4.8 The problems of contaminated land and buildings are perhaps, however, synthesized when sites of former chemical works, pesticide manufacture, or metal treatment works are considered. Macbeth's witches can rarely have conceived a more potent brew than the complex of problems which can exist on such sites and, perhaps worse, their associated tips. Any attempts to define a use for such sites should not begin with a pre-determined idea for a single, fixed use but a very open mind should be retained for as long as possible and certainly till the extent of the problem has been established.

5. The key to the re-utilisation of contaminated land lies, in fact, in such establishment of the extent of the problem. Whenever such sites are proposed for use, a full site investigation is an absolute prerequisite. This must include not only establishing the physical characteristics of the materials within and under the site but also the geology of the area and the hydraulic qualities of the area around the site in question. Hydro-geology, as with most natural sciences, is not an exact science but relies heavily on the interpretation of surveyed detail and on the professional experience and competence of the analyst. Consequently, care should be taken in interpreting and assessing the results of such surveys, bearing in mind the risk element, but also taking a pragmatic view of those risks. It is considered that the development of such sites is, in

fact, as much a matter of risk management as of any other quality.

5.1 In addition to the aspect mentioned above, chemical analysis is also vital to minimise risks. Because of the relatively random nature of sampling and testing in such cases, average values should not be used, but more weight should be given to actual concentrations present in assessing any treatment required. Equally, remedial measures taken should err on the generous side and calculations should be biased accordingly.

5.2 The need for investigation and analysis does not end with the initial survey of the site. It should be continued through the redevelopment of the land into its new use, carefully checking any materials which may be exposed and monitoring the effect of changes in levels or site loading. This monitoring should continue after the site has gone into its new use to ensure that longer term changes are not hostile to the new use and environment. No time period can be fixed for such subsequent monitoring but it will depend in large measure on the characteristics of the materials found on, and in, the land. Physical attributes are of importance here, in relation to settlement of the site and any structures on it, and gas production and leachate production can also be long term problems. Difficulties can arise in this respect when the land passes out of the control of the reclaiming authority, possibly losing the ability to continue monitoring. These difficulties are increased when the land is split into a number of different ownerships and the saying "Out of sight, out of mind" is too often true in this respect. Where such uses involve agricultural land, monitoring of results is particularly necessary, especially if there is a possibility of plant up-take of pollutants which might effect milk or beef production. Also, further treatment of the site may be necessary at regular intervals to make sure it does not regress. Acidic land can, for instance, require regular treatment with lime to ensure that plant life is not adversely affected, just as evolving problems with possible chemical reaction may necessitate further treatment.

6. All this - the initial acquisition, survey and site investigation, treatment and works process, monitoring and management - costs money - frequently a great deal of money. Such costs must obviously be looked at very carefully in the context of alternative courses of action and alternative new uses for the restored land. It is an unfortunate fact that the easiest new uses to achieve for contaminated land are not generally the most acceptable in land use planning terms, unless their is a willingness to accept some incongruity in neighbouring uses. Clearly, the easiest form of subsequent development is for a "soft" use such as public open space or agriculture. There is a limit, however, to the number of such areas which will be acceptable in, say, an intensive industrial development, but the costs of achieving a compatible development may be both prohibitive and impractical.

7. "Hard" uses are, typically, the most costly to achieve on most contaminated land sites. These can best be described as being "built", and include industrial buildings and uses, public and commercial buildings and offices, and housing. By their nature, they need firm ground on which to be built with good and consistent bearing capacity. On tipped land this can be very difficult to achieve without using piles or ground consolidation techniques. Ground condition can make pile driving or boring both difficult and expensive while there is often the risk of sulphate or acidic attack upon concrete, both in the piles and in foundations generally. The risk of gas collecting in basements, service trenches and drains and manholes is equally great and can preclude certain types of development to the extent that a different use has to be chosen. Even former industrial sites can be difficult in this respect, although, as indicated before, greater problems can rise from the remains of old foundations or other underground structures.

7.1 "Soft", uses, in terms of playing fields and public open space, agriculture, forestry, or allotments do not rely on firm foundations but are very susceptible to soil or ground pollution by heavy metals, polluting liquids and/or gases, or any combination of the three. A good thickness of inert cover over sites to be used for such purposes can be most beneficial, but such cover must not be capable of being affected by the materials it overlays. In certain instances, the incorporation of lime may be necessary, on considerable quantities, to neutralise problem materials uderlying the cover. In some cases, access to the site has to be obtained with care because of instability problems and working methods may have to be tailored to the particular difficulties of the site. Where allotments are concerned, these must be considered with particular care because of possible up-take of toxic metals into plant life. Research is by no means conclusive in this aspect of scientific work, and even tolerance levels for such hazards are not yet satisfactorily established.

7.2 Sites which are burning produce problems in a class of their own. Classic solutions have been to excavate the burning material, extinguish it or let it burn out and then bury it. The validity of this course of action depends, naturally, on what is buried and the risks involved in digging it up. The possibility is postulated that better results might come from boring (if able) into the tip and injecting a lime slurry to smother the combustion. Luckily, such problems are much more rare than they used to be, although they have not wholly disappeared.

8. Land is a finite resource. Too often in the past, and even still in the present, land was, and is, used wantonly, with little thought or precaution to preserve it for another use in the future. Industry has too many problems to deal with today to care very much about the tomorrow it will not see. It is not always selfish in its preoccupation with its own immediate concerns, but merely not orientated to considering matters beyond its own life. Nevertheless, efforts must be made to ensure that land is not so badly used that it is incapable of proper use in the future. If this Conference generates more interest and concern in

such matters, then it has made a valuable contribution towards the conservation of land and the renewal of a wasting asset.

9. The permission and encouragement of Mr. F.A. Sims, Executive Director of Engineering, West Yorkshire Metropolitan County Council, to present the paper is gratefully acknowledged by the author.

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THE LONG-RANGE TRANSPORT OF AIR POLLUTION - A DECADE OF INVESTIGATION

by

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It is amazing to reflect that, 12 years ago, when I was considering the topic to research for my PhD degree, most eminent authorities did not believe that pollutants could regularly travel in the atmosphere for more than a hundred or so kilometers. Indeed, I can remember well having to convince my supervisor that a study of the long range transport of air pollution (LRTAP) would not be a fruitless task and that it would not lead to my involvement with "scientific fringe elements"!

It was in 1968 that Europe was first alerted to the possibility that air pollutants could travel distances of 1,000 km or more. A network of stations for measuring the chemical composition of precipitation had been established in Sweden in 1947. In the 1950s this network was extended to a number of European countries (The European Air Chemistry Network - EACN), and was co-ordinated by the Institute of Meteorology at the University of Stockholm. About 10 years later, it was observed that the precipitation at many of these stations was gradually becoming more acid. A first analysis of the data by Oden in 1968 showed that a central area in Europe with highly acid precipitation (pH 3-4) was expanding from year to year. This observation was associated with the acidification of the water in rivers and lakes in Scandinavia, where in many places the fish population had disappeared.

These observations led to the OECD Co-operative programme on the long range transport of air pollution in 1972. Its objectives were to determine the relative importance of local and distant sources of sulphur compounds in terms of their contribution to the air pollution over Northern Europe with special attention being paid to the acidity of precipitation. The OECD study reported in 1977 but to this day represents the only comprehensive study of air pollution transport on a continental scale.

Concurrent with the OECD Study, a detailed research programme (Sur Nedbors Virkning Pa Skog Og Fisk - SNSF) was mounted by the Norwegian government to investigate the potential effects of acid deposition on the rural environment. This project ended in 1977 after defining more precisely than any other single investigation, either before or since, the ecological impact of LRTAP. In addition, many other researchers were actively engaged, throughout Europe, in the determination of the cause and effects of LRTAP.

While the scientific community worked towards an understanding of the processes leading to, and the impact of LRTAP, the subject was receiving a great deal of emotive treatment by the media and growing attention by some politicians. At the UN Conference on the Human Environment, held in Stockholm in 1972, a number of claims were made by some Scandinavian governments which still lack the benefit of scientific validation. At the present time these claims are being repeated in North America where the subjects of LRTAP and acid rain are the same burning issues that they were in Europe a decade ago. Indeed, the USA is currently spending over $5M p.a. on a research programme which in some cases, deals with questions which could be answered from the wealth of information and experience that has been accumulated in Europe over the past 10 years. It is perhaps time, therefore, to review what is known and what remains uncertain about LRTAP.

In the first instance it is essential to distinguish between the generalised term "Acid Rain" and the more precise title "Long Range Transport of Air Pollutants" (LRTAP). The latter relates specifically to the phenomenon which is now causing considerable concern in Scandinavia, Laurentian Canada and NE USA. Acidic precipitation in these remote areas is an integral part of the problem but so too is the dry deposition of acidic species emitted in distant industrial conurbations.

In contrast, acidic rain (i.e. <pH 5.6) per se is ubiquitous in all major industrial and urban areas and their hinterlands. This has been the case since the Industrial Revolution. The magnitude of acid deposition generally increases towards the areas of major emission and peaks centrally. The acid precipitation in the source areas is associated with elevated ambient SO_x and

NO_x concentrations (from which it is derived) originating from local combustion of fossil fuels. Together they produce the familiar problems associated with the acidic urban atmosphere viz. corrosion of metals, decay of building stone, ancient monuments, exterior paintwork and fabrics. In some cases distant sources (i.e. LRTAP) enhance the adverse effects due to local emissions but in general the ability to ameliorate adverse effects lies locally.

The problems associated with the urban atmosphere, and the mechanism for their abatement, have been understood for decades. The problems associated with LRTAP are due to:-

(1) The fact that pollutants can and do travel 1,000 km from their point of emission (even trans-Atlantic advection has been documented);

AND

(2) Certain remote ecosystems are particularly fragile and are disrupted by slight increases in acid deposition.

Within this broad framework of understanding lie a number of crucial technical factors which are unresolved and some upon which there is reasonable, but sometimes not total, international agreement. For succinctness it is proposed to catalogue these factors under subject headings.

1. EMISSIONS AND TRANSPORT

(a) Established Aspects

- Acid deposition at remote receptors is due to sulphur and nitrogen compounds roughly in the ratio 2 : 1. In some areas the ratio has reached 1 : 1.

- The majority of sulphur and nitrogen compounds reaching a remote receptor are in the form of sulphates ($SO_4^=$) and nitrates (NO_3^-).

- While some $SO_4^=$ and NO_3^- are emitted at source they represent $<10\%$ of the total SO_x and NO_x emission. The most common primary sulphur compound is sulphur dioxide and the most common nitrogen emission is nitrogen oxide. The latter is quite quickly oxidised to NO_2 after release. Gaseous SO_2 and NO/NO_2 primary emissions are removed from the atmosphere quite quickly, even in the absence of precipitation, by a process of surface adsorption called "dry deposition". This process is concentration dependent and hence declines in significance with distance from the source.

- Concurrent with the depletion of the primary SO_2 and NO/NO_2 emissions by dry deposition, atmospheric oxidative processes convert SO_2 to $SO_4^=$ and NO/NO_3 to NO_3^-.

- $SO_4^=$ and NO_3^- are only effectively removed from the atmosphere by precipitation (their dry deposition velocity is $<$ 10% of their precursors) and hence they represent the principal LRT species.

- LRTAP is fundamentally a response to high emission density - the atmosphere's natural cleansing mechanisms become overloaded and pollutants travel downwind as a "river" of foul air. For example the plume from a major point (e.g. Sudbury smelter, 1,617,000 t/SO_2/y) or area (e.g. German Ruhr, 850,000 t/SO_2/y) source would make a much greater contribution to LRTAP than the emissions of France (3,224,000 t/SO_2/y) a country with an area of 549,000 km^2.

- Certain climatological conditions favour LRTAP:-

Transport

(i) Stable airstream, low mixing height, moderate strong winds, no precipitation; conveys mildly polluted air quickly from source to receptor; typical of anti-cyclonic margins.

(ii) Stagnation of an airmass over a source area. The heavily polluted air eventually becomes drawn into a synoptic flow and very substantial depositions (up to 1/2 the annual total for one location) can occur in remote areas (called "episodes"). Typical of anticyclone centres.

Deposition

(iii) Convective systems such as thunderclouds or slowly moving convergent systems ("depressions") can draw in polluted air from a distant source and precipitate it out over a small area. If the system becomes stationary "episodes" can occur. The process is then analogous to orographic rainfall, probably the most common cause of acid rain.

- In Europe, LRTAP/acid precipitation is a pan-continental phenomenon in which a complex matrix of sources and receptors are linked almost at random by the ever changing weather. The situation in North America is similar but with both sources and receptors being in a box of 1000 miles centred on the St. Lawrence River Basin.

Areas of Uncertainty

- The atmosphere operates a complex range of oxidative processes by which primary pollutants are converted into the LRT species $SO_4^{=}$ and NO_3^-. In consequence, emissions of primary pollutants are not coupled directly to deposition at remote receptors.

  The efficiency of atmospheric oxidation processes is very sensitive to small changes in the concentration of certain atmosphere contaminants (e.g. sulphates and chlorides of iron or manganese; olefinic hydrocarbons) and to meteorological variables such as humidity, temperature, sunshine etc. Because atmospheric oxidation depends so crucially on the precise mix of pollutants in the atmospheric "reaction vessel" at any one time it is conceivable that a substantial reduction (e.g. 50%) in emission of primary SO_x and NO_x may not be reflected in a pro rata reduction, or, indeed, any reduction at all in $SO_4^=$ or NO_3^- formation. LRTAP would, in consequence, be unaffected.

The precise sensitivity of atmospheric oxidation potential to small changes in the primary pollutant mix requires urgent evaluation.

- The significance of past emission trends for SO_x and NO_x is still a matter of conjecture. In the first instance, there is no agreement on the base date subsequent to which LRTAP and its alleged adverse effects began to occur. It is often claimed that LRTAP is a post-World War II phenomenon but such claims are usually based on the historic limit of reliable observations.

  In Europe there is documentation to indicate LRTAP was occurring soon after the turn of the century. The two base-lines are not necessarily mutually exclusive, however, since the effects of LRTAP would be insidious and hence their widespread recognition might await the mobility, instrumentation and scientific awareness of the population at large, which are fundamentally post-1950 phenomena, or a progressive worsening of adverse effects or both.

  Historical data on possible effects of LRTAP in North America is even more scanty and conflicting than that from Europe. Indeed, unlike Europe there is not even any unambiguous evidence to support the view that precipitation acidity in NE.USA/Laurentian Canada has increased in the recent past. Moreover, even assuming that in North America the situation has worsened since World War II, the historical emissions data do not support the view that an increase in sulphur is the only, or even primary, cause.

  For example, in the USA as a whole, sulphur emissions from fossil fuel burning in 1970 were very little different from those experienced in the 1940s (Figure 1). When other sources, such as ore smelting are added on, a modest rise of 17% occurred between 1950 and 1975 (Figure 2). The NE. USA saw an increase in emissions of approximately 50% over the same period, suggesting that a spatial reorganisation of major sources may have been taking place. In contrast, US nitrogen oxide emissions show an increase of about 200% from 1940 to 1978 (Figure 3).

In Europe a similar picture emerges. Between 1950 and 1970 sulphur emissions doubled (Figure 4) whereas nitrogen oxides emissions incresed fourfold.

- LRTAP is insensitive to the height of precursor emissions providing these are made into the atmospheric "mixing layer". Under such circumstances, the emissions from a tall stack would contribute about 15% more acid deposition to a receptor 1,000 km distant than an emission of similar magnitude much closer to the surface. However, it is unclear how often such tall stack emissions are made above the mixing layer. During such occasions the entire precursor emission could be converted to $SO_4^=$ or NO_3^- and transported undepleted by dry deposition to a distant receptor.

2. EFFECTS

It is still a matter of active controversy between some experts whether acid rain has any negative effect on the environment at all. However, in general, there is a concensus that certain claims are valid while others need the benefit of more detailed experimental evaluations before firm conclusions can be drawn.

(a) Established Claims

- The LRT of sulphate aerosols can impair visibility over wide areas remote from the source of their precursors. Nitrates are much less effective in light scattering than sulphates and hence play only a minor role in such visibility impairment.

- Forests in receptor areas do not suffer from acid deposition as was first supposed. Detailed investigations have shown that the fertilizer effect of nitrates in acid precipitation tends to counterbalance any potential negative effects due to the presence of sulphur. Indeed, there is even some suggestion that trees grow better with nitrate-containing acid rain than without it, provided pHs do not fall to very low levels.

- Agricultural soils and other land under intensive management is unlikely to show any adverse effect from acid deposition because of the regular application of alkali-containing fertilizers, lime, etc.

- Where acid deposition occurs in an ecosystem which has a severely limited "buffering" capacity (alkali deficiency), surface water pHs may fall below levels that might have occurred naturally. This affects aquatic life at all levels: acidified lakes exhibit substantially lower photoplankton biomass and species variety as compared with non-acidified lakes; acid waters have fewer species of benthic invertebrates and herbivorous zooplankton than those with lower acidities; most emotive of all, increasing lake and river water acidity has a strong negative effect on fish populations and species variety.

  Some lakes and rivers, formerly with resident fish populations are now completely fishless. The decline in fish populations is due primarily to recruitment failure but some instances of "fish-kills" have also been observed. These incidents, in which a river, or a section of a river, loses its entire fish (or species) stock in a single incident, have been linked to flushes of very low pH water. Such flushes are often associated with the first spring snow-melt (acidic snow melts first and runs over the still frozen ground directly into lakes and rivers) or the first rains after a long dry summer (soil purged of accumulated dry deposition). In most cases disturbance of the normal ion and acid-base balance is the most likely reason for mortality although the mobilisation at low pH of toxic metals such as aluminium may also be a contributory factor.

It is important to note that areas experiencing fish depopulations are confined to water courses with particularly poor natural buffering capacity. Indeed, even in the absence of anthropogenic emissions these very fragile catchments would be on the very threshold of supporting vertebrate species. In certain cases some lakes in the sensitive areas are thought to be naturally fishless.

(b) Aspects of Uncertainty

- Because fish depopulation is a consequence of deficiencies in the receptor area, as much as it is to LRTAP, various other mechanisms have been identified as contributory causes. In particular, changes in the pattern of land use are the focus of attention.

  There is some evidence to suggest that where pines grow, especially when they are cultivated on a commercial basis, surface water drainage becomes acidic without the intervention of LRTAP. Other, more parochial, issues include the influence of acid mine drainage and abandonment of mountain pastures. However, even if substantiated, these essentially local factors could not explain the much wider occurrence of observed pH depression in lakes and rivers.

- The long-term effect of LRTAP on (unmanaged) soils remains unclear. Soils are very varied in character, have a very complicated chemistry and substantial inertia; responses to an insidious stimulus such as acid deposition are only likely to manifest themselves over a long period of time. For this reason a decade of research has failed to produce any clear picture of what may become of (unmanaged) soils in receptor areas.

  However, the range of fates awaiting acid precipitation which passes into the soil is now better understood. This range appears to include three possibilities:-

(i) The hydrogen ions of acid precipitation may be neutralised by alkaline salts such as calcium carbonate.

(ii) The surface of clay minerals and humus, being predominantly negatively charged, adsorb positively charged cations such as calcium, magnesium, sodium and potassium. The hydrogen (cat) ions in acid precipitation may exchange with these cations in the soil, the capability of the colloids to retain exchangeable cations being called "cation exchange capacity". The higher the cation exchange capacity of the soil the more able it is to withstand the detrimental effects of acid precipitation.

The soil also contains heavy metal cations such as cadmium, nickel, lead, manganese and mercury bound to colloidal particles. Excessive amounts of hydrogen cations introduced into the soil by acid precipitation may exchange for these heavy metal cations, thereby releasing toxic heavy metals into the soil. Other toxic cations such as aluminium may also be mobilised.

(iii) Acid precipitation may leach through the soil and enter the ground or drainage water. In doing so, alkaline cations such as calcium and magnesium, important for growth, together with mobilised toxic cations (heavy metals, etc.) will be removed from the soil and enter the aquatic ecosystem.

In general it appears that thin, marinal soils, developed in mountainous areas on igneous or metamorphic rock, are the most at long-term risk, while the deep, robust soils of lowlands and those developed on sedimentary substrates, seem unlikely to suffer.

- It is unclear to what extent soil micro-organisms are affected by acid precipitation. Experiments with synthetic acid rain, never likely to yield conclusive results, suggest that microbiotic life in the soil is inhibited and hence the decomposition of organic matter and the cycling of nutrients and chemical elements could be impaired.

- The poor understanding of soil/rain water chemistry also extends to the role played by the soil in determining the chemistry of water entering streams and rivers. It is often forgotten that only in areas with bare rock or where precipitation impacts directly on the water surface, is precipitation chemistry not influenced by the soil. At present research has only been able to establish that no short term relationship exists between precipitation chemistry and ground water quality. This suggests that the soil has a major impact on the composition of water entering lakes and rivers.

- A similar picture to that already established in the case of forestry is beginning to emerge in the context of other vegetation, including crop species viz. acid precipitation does not appear to have any negative effect on growth rate, yield or leaf area provided, pHs do not fall to very low values. This lack of response may be due to the widespread nitrogen and, to a lesser extent, sulphur deficiency in many soils.

  Experimenters who claim to have demonstrated adverse effects on plants or crops have used "synthetic" acid rain of a strength and/or quality unrelated to real precipitation. Even when damage to plants has been occasioned by the use of unnaturally low pH "rain" (often pure sulphuric acid) the "damaged" plants usually recover quickly and fail to show any statistically significant difference in terms of leaf area or yield, compared with controls, by the end of the growing season.

- There has also been some suggestion that acid deposition reduces the reproductive potential of trees and plants by lowering the rate of successful seed germination. Until such findings have been confirmed in the field and with real acid rain, such claims must remain conjectural.

- When sulphate and nitrate aerosols travel over long distances, they alter the atmospheric albedo over significant areas. It is not known if the impact of such modifications on the Earth's radiation budget is sufficient to effect any appreciable climatic modification.

  Sulphate and nitrate aerosols might also increase cloud amounts and precipitation frequency by acting as condensation nuclei. In general, however, the atmosphere has only local deficiencies in condensation nuclei and hence any increase in their number is unlikely to be of any great meteorological significance.

- Although concern has been expressed in North America about the effects of LRTAP on human health and welfare, these claims remain speculative, lacking the benefit of either theoretical or observational support. They fall into four groups:

  (i) After transport over long distances the concentrations of sulphate and nitrate aerosols are reduced to a level which is not known to have adverse effects on the human respiratory system.

  (ii) Acid precipitation has always been more intense in source areas than at distant receptors. However, there have never been any claims by city dwellers of precipitation being sufficiently acid to cause discomfort or damage to the hair, eyes or skin. It therefore seems unlikely that any such effects would be observed by residents of distant receptor areas where acid precipitation is more moderate.

(iii) Attention has been drawn to the theoretical possibility that acid precipitation may cause potable water supplies to be contaminated by toxic elements. This could occur both by the mobilisation of toxic metal ions as rainfall leaches through the soil and from the corrosion of metal supply pipes, especially where these are lead or have lead joints.

However, this is unlikely to occur where water quality is controlled in treatment plants according to established standards. If local problems did occur, these would be detected in the routine quality analyses that the law requires to be carried out and ad hoc remedial action could be taken.

(iv) There are claims that materials, paintwork, structures and heritage may suffer damage from LRTAP. At present these claims are unsupported by observational evidence because it is difficult to isolate the effect of pollutants transported from distant sources from those due to local emissions. However, in the vast majority of cases, any damage due to atmospheric acidity or deposition will be much more a consequence of local sources than of distant ones.

3. SUMMARY

- Most pollutants which undergo LRT are usually accepted into the receptor environment without adverse effect. The majority of soils and watercourses have sufficient latent buffering capacity to neutralise acid deposition.

- In certain localised areas, often remote and inaccessible to the general public, adverse effects on fresh water life have been identified. The vulnerable ecosystems are invariably in regions developed on igneous or metamorphic rocks where soils are either thin or absent.

- The LRT of sulphates reduces visibility over wide areas.

- Many other adverse effects of LRTAP have been claimed, but none, as yet, has been substantiated. The most likely additional threat to be established is the impact of LRTAP on thin mountain soils.

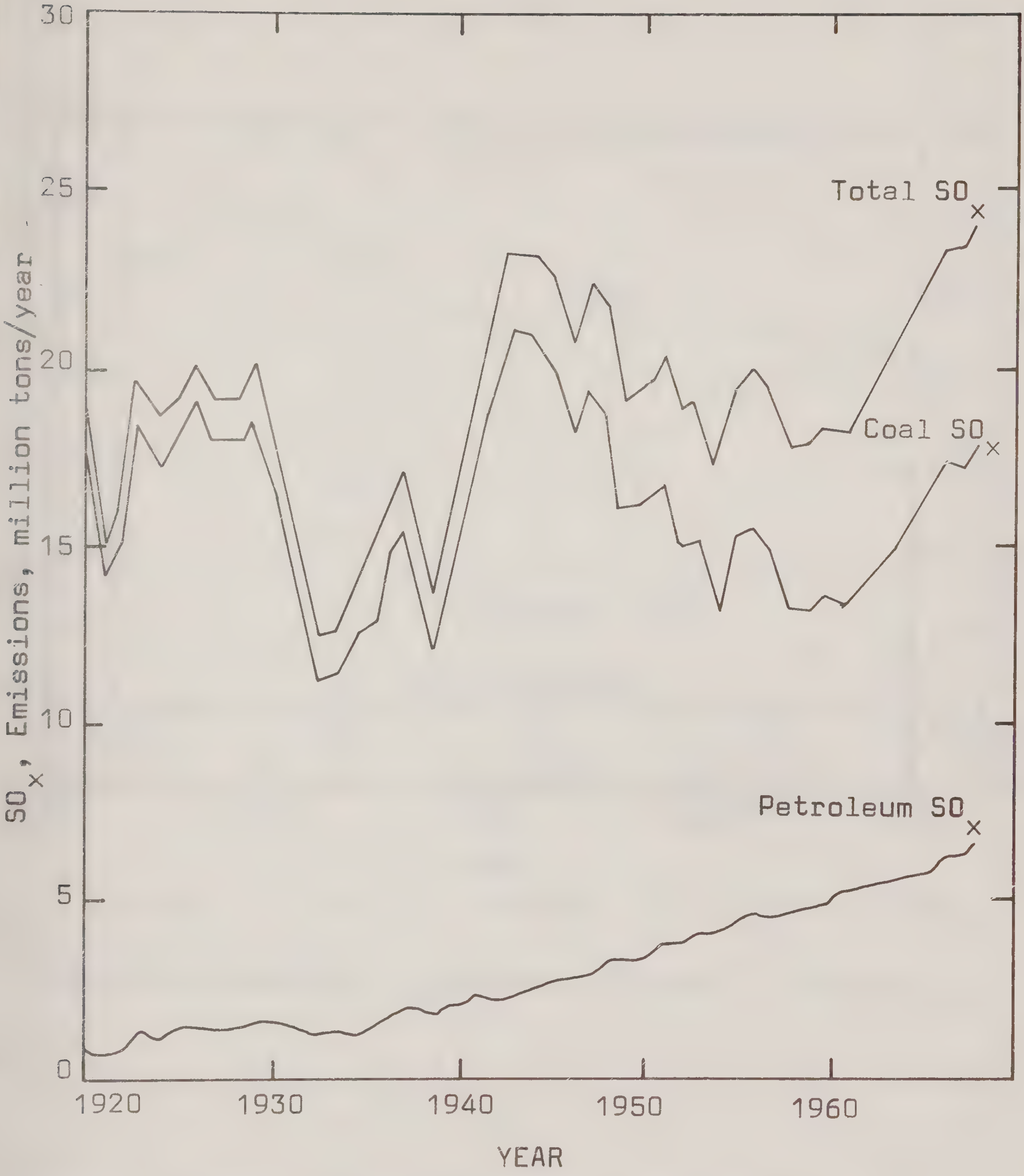


Figure 1 Sulphur Oxides Emissions From Fossil Fuel Combustion, Millions of Tons Per Year (Land, 1976)

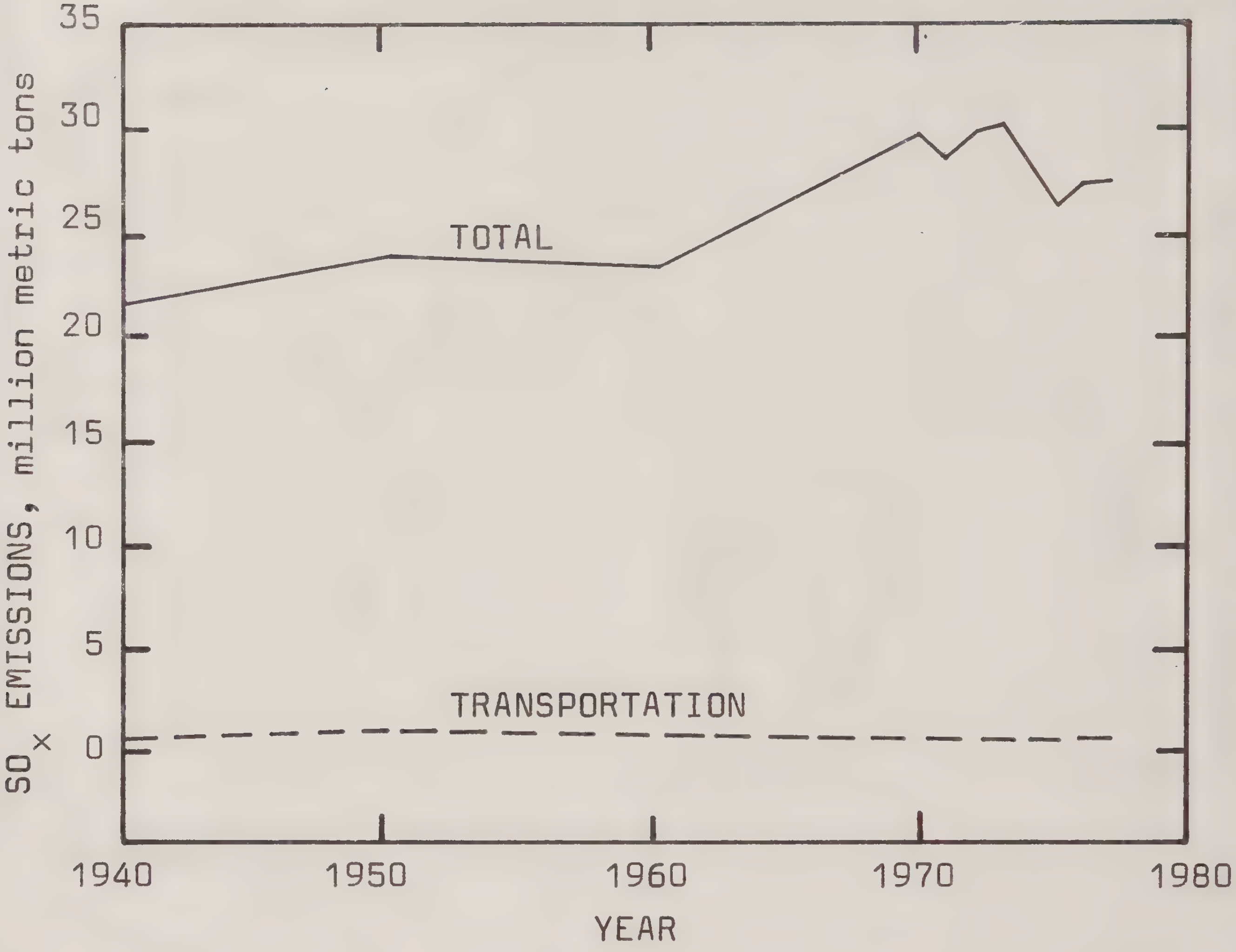


Figure 2 Trends in emissions of sulphur dioxides.

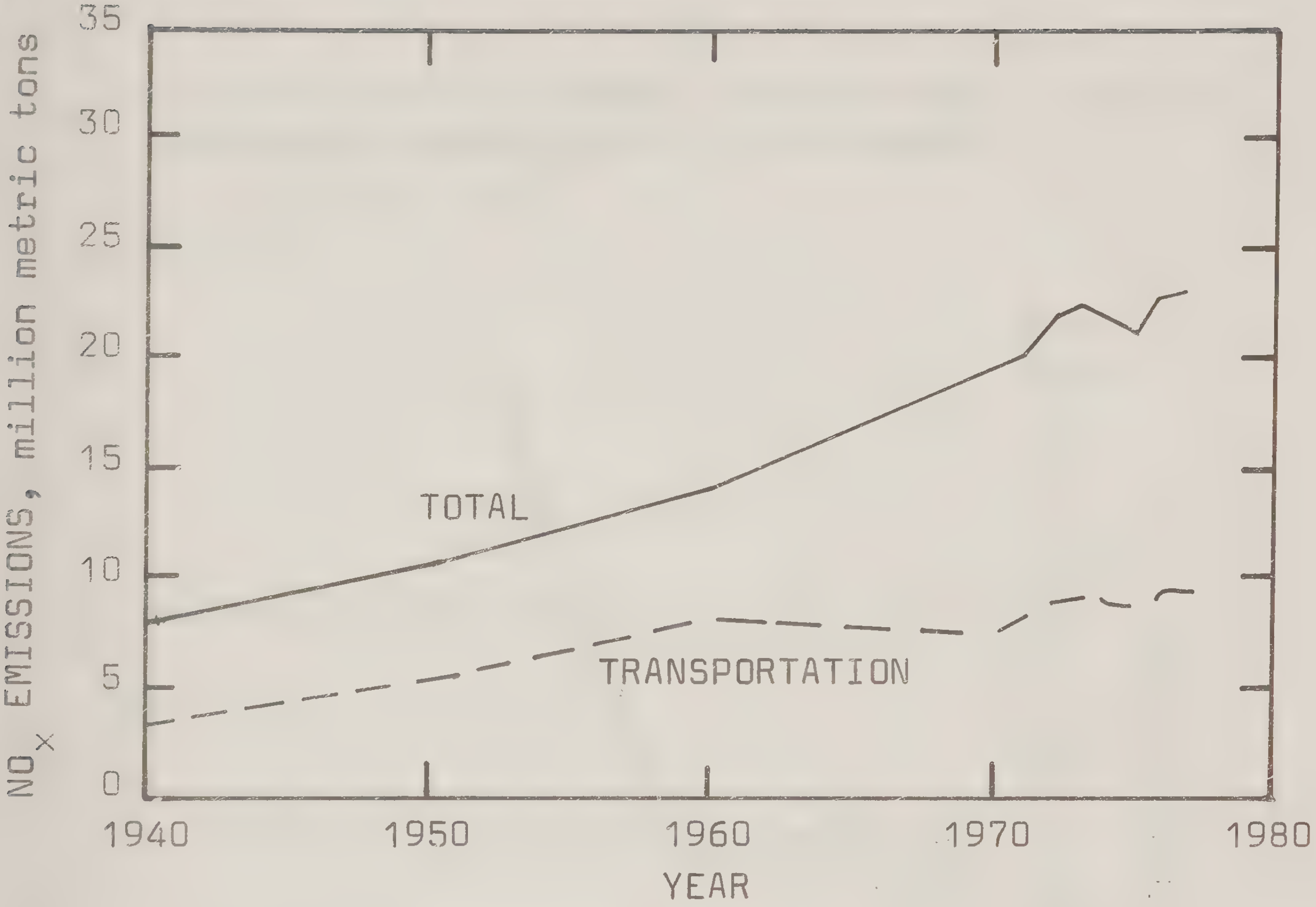
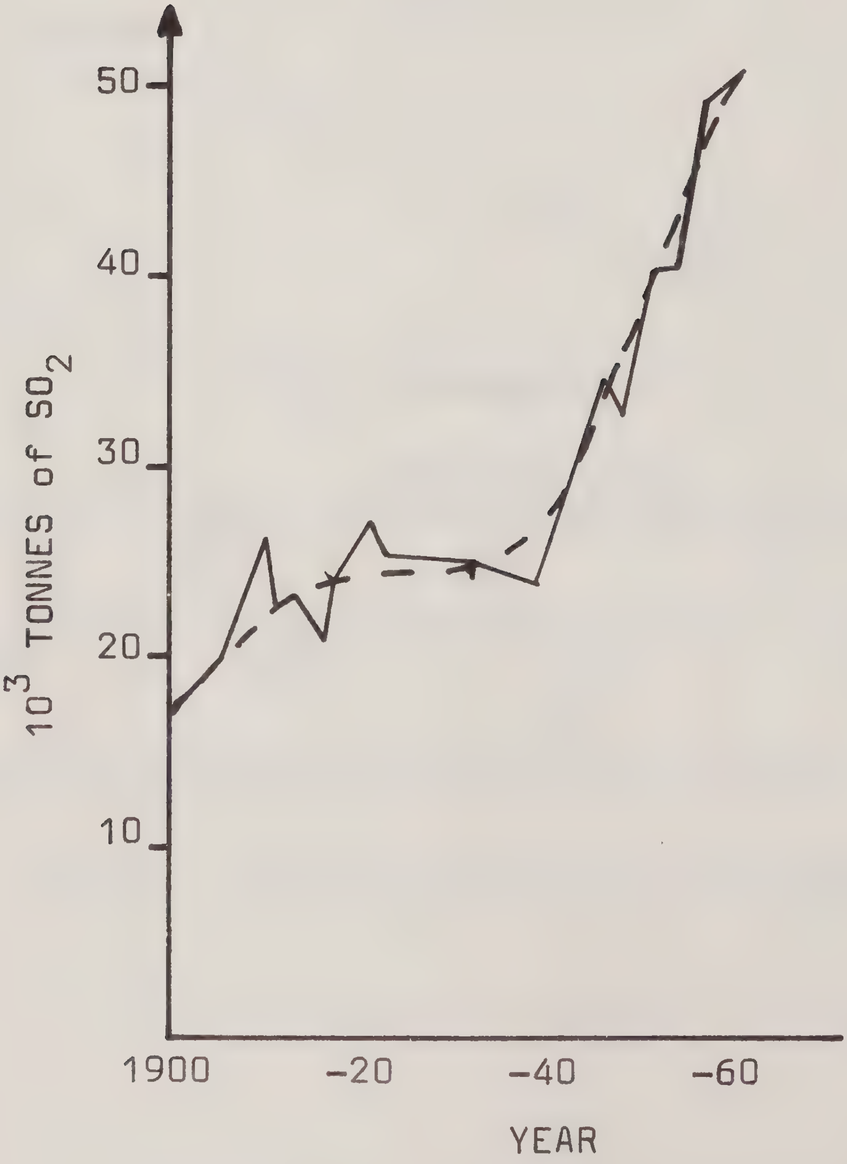


Figure 3 Trends in emissions of nitrogen oxides.

Figure 4 Emissions of sulphur dioxide from the Combustion of fossil fuels in Europe



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CHEMICAL TRANSFORMATIONS IN THE ATMOSPHERE

by

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1. INTRODUCTION

In the past, concern over the emission of pollutants into the atmosphere has centred on possible adverse health effects and on visible damage to agriculture at high pollutant concentrations. With large stationary sources, such as coal or oil fired power stations, the principle of control is to make sure that a sufficiently high dilution is reached at the point of impact that the concentrations are well below the levels expected to cause harm to people or the environment. To achieve this power stations are equipped with chimneys which are tall enough to give adequate dilution even under the most adverse meteorological conditions and, in the case of coal-fired power stations, with high efficiency electrostatic precipitators to minimise particle emissions. For example, the tallest power station chimneys are in excess of 200m in height and give a typical dilution of about 10,000 at ground level at the point of maximum impact. This strategy is based on a fairly detailed understanding of the dispersion and the transport of primary pollutants in the near field which enables reasonably accurate predictions to be made of pollutant concentrations derived from a particular source under a variety of meteorological conditions.

The first indication that the chemical transformation of primary pollutants to other products in the atmosphere might be of significance in determining effects arose in the 1950s when photochemical smog formation became recognised as a major problem in the western United States. More recently in Europe, North America and other parts of the world, much attention is being given to the effects of long range transport of pollutants - especially SO_2 - and, in particular, to the possible relationship between emissions and the acidity of precipitation (rain and snow) at receptor sites sometimes hundreds of kilometres from the pollutant source. Transport over such distances can take several days which is a sufficiently long time for major chemical changes to have taken place. This paper summarises some of the important processes which are thought to occur in both photochemical smog situations and during long range transport from point sources.

2. THE CHEMISTRY OF PHOTOCHEMICAL SMOG

As early as the 1930s it had been observed that Los Angeles suffered from the phenomenon now known as photochemical smog. The outward manifestations were reduced visibility, associated with aerosol formation, along with sometimes severe eye irritation and plant damage associated with high levels of oxidant such as ozone. The observation that the oxidant concentration was correlated with incident solar radiation led to the inevitable conclusion that chemical processes initiated by sunlight were responsible for oxidant formation and it soon became evident that the pollutants which give rise to these reactions are organic compounds and oxides of nitrogen arising from the combustion of fossil fuels. The chief source was identified as automobile exhaust. A third factor, in addition to sunlight and high emissions, makes Los Angeles in some respects unique. That is the prevailing meteorological and geographical situation which leads to the development of a stable temperature inversion for about 320 days of the year on average. Nevertheless photochemical smogs - that is high levels of oxidants induced by sunlight - are now observed on occasions in various urban areas of the world including, very occasionally, the UK although in many instances their existence remains unsuspected and can only be detected using the most sensitive instruments. For example Fig. 1 shows profiles of SO_2, NO_x and O_3 during an aircraft traverse along the east coast of the UK in June 1980 during an exercise to track a power station plume. The peak of ozone (100 ppb) observed at about 12.24 GMT can be traced back to its area of origin using the recorded wind data and also the observed power station plume as an additional reference. The ozone "plume" undoubtedly originated from the Tees-side area and represents clear evidence of photochemical activity in the air from Tees-side on that occasion.

In general, measurements of pollutant concentrations show quite large fluctuations over short time scales.

Similarly the amount of solar radiation can vary from minute to minute according to cloud cover etc. However, by taking averages over a long enough period, the diurnal variations of the various atmospheric components can be established and Fig. 2 illustrates, schematically, a typical photochemical smog cycle. The cycle starts with fairly low levels of primary pollutants, that is nitric oxide, NO, and hydrocarbons, and these rise rapidly as automobile activity starts in the early morning. Thereafter the emitted NO is converted fairly rapidly to nitrogen dioxide, NO_2, which reaches a peak before noon. Later in the cycle ozone increases and hydrocarbons are oxidized to aldehydes and nitrocompounds including, particularly, peroxy-acetyl-nitrate (PAN).

Such behaviour can be reproduced in the laboratory in chambers irradiated with sunlight or artificial light and using either automobile exhaust diluted with air or mixtures of precisely known chemical composition made up in the laboratory. The physical symptoms such as eye irritation can also be reproduced and the specific substances responsible including formaldehyde and PAN have been largely identified.

The number of primary pollutants which could potentially take part in the chemical reaction sequences is quite large. Table 1 lists 26 hydrocarbons alone that have been identified in polluted air in California (Stephens and Price, 1972). When secondary and intermediate products of reaction are added to these, along with the major natural components of the atmosphere, it is clear that the number of individual reactions could be very large indeed. It is therefore necessary to resort to laboratory studies to to characterise them. In this respect the parameter of primary interest is the rate at which a particular reaction proceeds. In particular, if there are two possible pathways for reaction of a particular substance the faster route will be the predominant pathway.

An example is the oxidation of nitric oxide. Two possible reactions in the atmosphere are oxidation by oxygen

$$2\ NO + O_2 \rightarrow 2\ NO_2 \tag{1}$$

and oxidation by ozone

$$NO + O_3 \rightarrow NO_2 + O_2 \tag{2}$$

Under typical atmospheric conditions in urban air reaction (2) is an order of magnitude or more faster than (1) and so oxidation would normally proceed exclusively via reaction with ozone.

The rate at which any elementary reaction proceeds is proportional to the concentrations of the reactants. Thus the respective rates of the above reactions are

$$\text{Rate (1)} = k_1 \ [NO]^2 \ [O_2]$$

$$\text{Rate (2)} = k_2 \ [NO] \ [O_3]$$

The constants of proportionally k_1 and k_2 are rate constants and are characteristic of the particular reaction. Rate constants for very many of the elementary reactions occurring in the atmosphere have been determined in laboratory experiments so that if the concentrations of the reactants are known the relative importance of the reactions can be assessed. In very simple cases this can be done by inspection, but in systems of any complexity, it is necessary to resort to the use of a computer. The rate of a reaction is a measure of how the concentration of a product changes with time. It may be intimately linked with that of another reaction if, for example, the product of one reaction is a reactant in another. What the computer does is to solve these coupled rate equations and the output result is a prediction of how the concentrations of all components - primary reactants, intermediates and products - vary with time. In other words, the computer has simulated or modelled the smog time-cycle such as shown in Fig. 2.

Considerable success has been achieved in modelling smog chamber experiments which are not complicated by fluctuations in sunlight or turbulence and other meteorological variables. It is more difficult to model real situations where the chemical reactivity has to be coupled to some kind of dispersion model in which cleaner ambient air may be mixing with, and diluting, the air in which the smog is developing.

To account satisfactorily for all the features of a smog cycle, and particularly the time dependence of aldehyde and other oxidant formation, often requires the inclusion, in a model, of more than one hundred elementary reactions. However, some, at least, of the basic features can be understood in terms of just a few of the more important reactions. Direct observation of the atmosphere as well as laboratory chamber experiment show that the smog cycle does not proceed in the absence of radiation. Thus light from the sun supplies the energy to initiate reaction and to achieve this light energy has to be absorbed. Many of the gases present in a polluted atmosphere are transparent to sunlight and cannot, therefore, absorb the radiation. Others, such as SO_2, may absorb radiation but there is insufficient energy available to cause the molecule to dissociate or react chemically so that it simply loses that energy by non-reactive collision with other molecules or by re-radiation. We now know that the main reaction which initiates the smog cycle is the photolysis of nitrogen dioxide

$$NO_2 \xrightarrow{\text{sunlight}} NO + O \qquad (3)$$

to yield nitric oxide and a free oxygen atom. Free oxygen atoms are extremely reactive and quickly attack oxygen molecules - the most abundant gas present apart from nitrogen - to yield ozone

$$O + O_2 + M \rightarrow O_3 + M \qquad (4)$$

where M is a "third body" molecule the presence of which is necessary to remove the energy liberated during the reaction.

The net result of reactions (2) - (4) is effectively

$$NO_2 + O_2 \underset{}{\overset{\text{sunlight}}{\rightleftarrows}} O_3 + NO \qquad (5)$$

and, in the absence of other reactions this would lead to an equilibrium or a photo-stationary state with no subsequent net conversion of NO to NO_2. In fact we know that this conversion does occur and the key to understanding the mechanism comes from the observation that added carbon monoxide enhances the development of a photochemical smog (Westberg et al, 1971). The only reaction of CO which can be fast enough to be significant is the reaction with hydroxyl free radicals

$$CO + OH \rightarrow CO_2 + H \qquad (6)$$

Hydroxyl radicals are known by measurement to be present in the atmosphere and we shall see in Section 3 that their reaction with SO_2 forms a major route for its removal from the troposphere.

In just the same way that O atoms react rapidly with O_2 (reaction 3) so do the even more reactive H atoms.

$$H + O_2 + M \rightarrow HO_2 + M \qquad (7)$$

And finally HO_2 can oxidise NO to NO_2

$$HO_2 + NO \rightarrow NO_2 + OH \qquad (8)$$

which is not only a route for NO_2 formation but also regenerates OH.

In the presence of hydrocarbons, a proportion of the free radicals O and OH attack the hydrocarbon molecule which we designate RH

$$RH + O \rightarrow R + OH \qquad (9)$$

$$RH + OH \rightarrow R + H_2O \qquad (10)$$

Once again the predominant route for the free radical R is reaction with oxygen

$$R + O_2 \rightarrow RO_2 \qquad (11)$$

We thus have yet another possible route for the oxidation of NO

$$RO_2 + NO \rightarrow RO + NO_2 \qquad (12)$$

Subsequent reactions of RO and other pathways for RO_2 lead to the formation of aldehydes acids and nitro compounds including PAN.

3. TRANSFORMATION IN POWER STATION PLUMES

A principal interest in describing chemical changes in power station plumes is that of accounting for the oxidation of sulphur dioxide to sulphate aerosol and the ultimate incorporation of acidic sulphate species into rain and snow. Current knowledge suggests that there are two main pathways. The first is through gas phase reactions initiated photochemically by sunlight most of which are identical with those of importance in photochemical smogs and leading to the formation of sulphate aerosol. The second route is thought to be important under cloudy conditions and involves the dissolution of SO_2 into cloud droplets followed by oxidation to sulphate by dissolved oxygen, ozone or hydrogen peroxide.

3.1 GAS PHASE REACTIONS IN PLUMES

Just as it is possible to simulate the photochemical smog cycle using data for elementary reactions determined in the laboratory, so, in principle, it should be possible to model the chemistry of a power station plume. However, in the case of a plume, there is the additional problem of combining the effects of rapid dilution with the influence of simultaneously occurring chemical reactions. In some instances the rate determining step may be dilution and mixing rather than chemical processes. An example is the oxidation of nitric oxide in a plume which, after the first few seconds of travel is predominately via reaction (2)

$$NO + O_3 \rightarrow NO_2 + O_2 \qquad (2)$$

In this instance the ozone is derived from the ambient air into which the plume is diluting and, for the first few tens of kilometres travel at least, NO in the plume exceeds ambient O_3. The result is that O_3 is depleted within the plume because reaction (2) is so rapid, so that all the reaction subsequently proceeds at the plume edge where further ambient air (and O_3) are mixing. The slowest process is the mixing which thus determines the overall rate.

From the profiles shown in Fig. 1 the decrease in O_3 within the plume relative to the ambient level is clearly evident. Such measurements show that, in sunlight, the photostationary state (4) is often established within the plume.

Many attempts have been made to measure the rate of oxidation of SO_2 in plumes at distances up to about 100 km using aircraft-borne instruments. This cannot normally be done by simply measuring SO_2 concentration profiles first because the oxidation rate is so small that the expected change would be indistinguishable from the measurement error and secondly because loss of material by dry deposition is in any event about as fast as chemical transformation. It is therefore, necessary either to measure out to longer distances or to measure reaction product, that is sulphate aerosol. The usual procedure is to take integrated filter samples during complete traverses of the plume.

Measured oxidation rates vary widely from zero to 50% hr^{-1} but generally average rates of the order of 1-2% hr^{-1} are observed. Gillani and Kohli (1980) has shown that the variation in observed rates can be further rationalised if allowance is made for the ambient ozone level, the degree of solar insolation in each case and the height of the atmospheric mixing layer. This immediately suggests that the oxidation may be initiated by sunlight and that ambient air quality may be important. Model calculations support and confirm this view.

In our reactive plume model developed at CERL (Cocks and

Fletcher 1981, Cocks, Fletcher and Kallend 1981) the plume is assumed to expand at a predetermined but variable angle vertically to fill the atmospheric mixing layer and horizontally at a different angle which can also be varied. As it expands it is diluted by ambient air which itself can be of variable composition but which must include the appropriate amounts of hydrocarbons, SO_2, NO_x, O_3 etc. for the particular situation (e.g. typical rural, urban etc.). We assume that the gases are uniformly mixed within the plume. The amount of incident sunlight for the time of the year and time of day is also an input parameter. The ambient air itself is, of course, reactive and so we calculate the difference that the presence of the plume makes in SO_2 conversion for example.

Fig. 3 shows the predicted conversion rate averaged over a period of about 6 hours from just after noon at latitude $50^o30'$ N for an ambient air composition corresponding to average rural air. The importance of the ambient air quality is illustrated indirectly in Fig. 4 which shows the relative contributions of the four major elementary reactions in which SO_2 is oxidised

$$OH + SO_2 \rightarrow HSO_3 \tag{13}$$

$$HO_2 + SO_2 \rightarrow HSO_4 \tag{14}$$

$$RO_2 + SO_2 \rightarrow RSO_4 \tag{15}$$

$$NO_3 + SO_2 \rightarrow SO_3 + NO_2 \tag{16}$$

and which are all thought to lead ultimately to acidic aerosol. The radicals RO_2 derive from hydrocarbons which, in the model (and in the real situation) come exlusively from the ambient air. The relative contribution of reaction (8) thus depends directly on the hydrocarbon content of the ambient air. Under some circumstances calculation indicates that it could account for more than 50% of the oxidation rate of SO_2.

In addition the OH concentration also depends materially on the ambient air composition. In Fig. 5 the difference in predicted oxidation rate of SO_2 for different ambient air compositions is shown. Dilution with pure air, that is simply 20% oxygen and 80% nitrogen, would cause the reaction to effectively cease.

Clearly then it is not possible to describe adequately the fate of one pollutant, for example SO_2, without considering the influence not only of other substances, such as NO, derived from the same source, but also of the components of the ambient air into which the plume is mixing.

3.2 ATMOSPHERIC REACTIONS IN CLOUDS

A major route through which SO_2 and its derivative are ultimately removed from the atmosphere is by wet deposition in rain and snow in which it is found as sulphate. A typical value of sulphate concentration in rain in areas remote from major sources is about 70 microequivalents per litre with values as high as 250 microequivalents per litre during episodes of high deposition. Calculations suggest that such levels cannot be reached simply by scavenging of either SO_2 gas or sulphate aerosol by falling rain (Marsh 1978) and point to the likelihood that pollutant materials are already present in cloud water before precipitation occurs. Sulphur dioxide is a fairly soluble gas and it has been suggested (Penkett et al 1979) that atmospheric oxidation to sulphuric acid can actually take place in clouds. This prediction is based on laboratory measurements which show that SO_2 in aqueous solutions can be fairly rapidly oxidised by dissolved oxygen, ozone or hydrogen peroxide. Oxygen, of course, is abundantly present in the atmosphere but is sparingly soluble. Ozone is less abundant, but more soluble and more reactive. Hydrogen peroxide is even less abundant but is much more soluble and highly efficient at oxidising SO_2.

In order to establish the importance of this pathway, several research groups throughout the world have recently been attempting to collect and analyse cloud water and, in particular to measure the acidity (pH) and sulphur content.

Table 2 compares precipitation composition for a remote site with the average composition of cloud water samples collected over the last two years during aircraft flights made by CERL. Although the cloud type and meteorological situations varied, the general picture emerging is that clouds, on the average, have concentrations about ten times higher than precipitation. The ratios of the various components are, however, about the same in both cloud and precipitation, as might be expected. pH values in cloud water of less than 3.0 have been observed during these experiments and also recently by groups in the United States (Hobbs 1981, Falconer and Kadlecek 1980).

Laboratory work shows that neither the reaction with dissolved oxygen nor that with dissolved ozone can proceed far enough to produce pH values as low as those observed. The overall rate of oxidation by hydrogen peroxide, however, is independent of pH (Cocks and McElroy, 1981). Thus the concentrations of sulphate and the acidity found in clouds can only be accounted for either by incorporation of acidic aerosol produced by gas phase reactions or by the oxidation of SO_2 by hydrogen peroxide. Direct measurement of hydrogen peroxide in cloud water is now being attempted. In addition aircraft flights under cloudy conditions to measure SO_2 oxidation rates are being attempted by several research groups. The results of these measurements will enable many of the outstanding questions involving chemical pathways of major pollutants like SO_2 to be resolved during the next few years.

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Table 1

Hydrocarbons found in unreacted morning air at Riverside, California

29 Jan 1970 0750 PST

Ref: Stephens, E.R., and Price, M.A., Journal of Colloid and Interface Science, (1972) 39, 279

Methane
Ethane
Propane

Ethene
Acetylene

Propane
Methyl acetylene
1,3 - Butadiene

1 - Butane
Isobutene

trans-2-Butene
cis-2-Butene

2-Methylbutene

Cylopentene
trans-2-Pentene
2-Methylbutene-2

Isobutane
n-Butane
Isopentane
n-Pentane
Cyclopentane
2,2-Dimethylbutane
2,3-Dimethylbutane
2-Methylpentane
3-Methylpentane

n-Hexane

Table 2

COMPOSITION OF CLOUD AND PRECIPITATION

Micro-equiv./litre	SO_4	NO_3	Cl	Na	K	Ca	Mg	NH_4	pH
Cloud, mean upwind UK	261	73	1154	905	112	53	237	126	4.3
Cloud, mean downwind UK	558	240	857	576	27	163	169	419	3.5
Precipitation mean OECD sites N1-N10	60	27	112	100	-	12	22	30	4.35
Precipitation episode S.W. Norway (2-4/3/74)	230	150	-	-	-	65	27	180	3.92

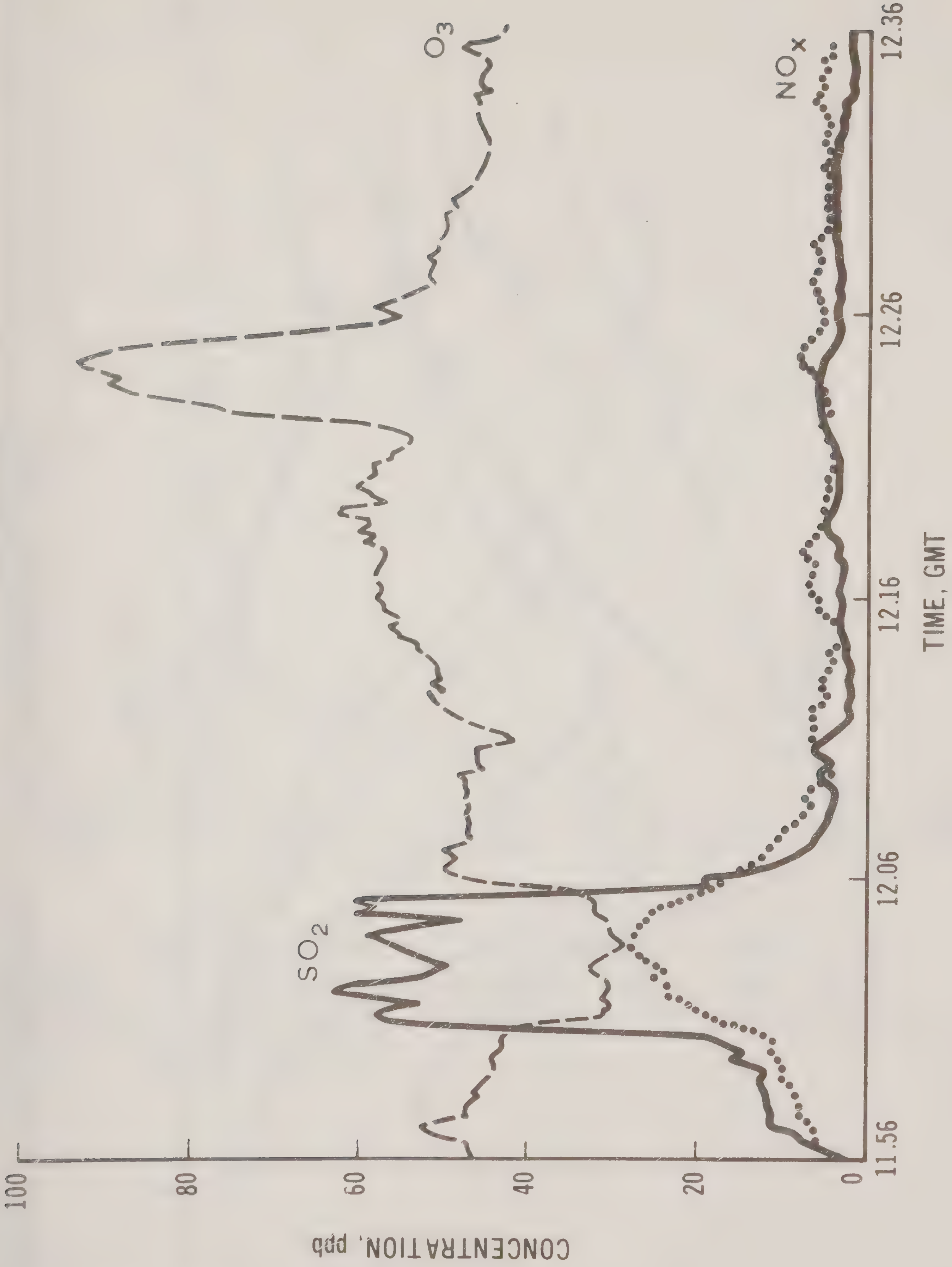

Fig. 1 SO_2, NO_x and O_3 profiles during a S → N cross-wind traverse of the Eggborough P.S. plume, June 18th 1980. The O_3 peak is directly downwind of the Tees-side area and is evidence of photochemical activity.

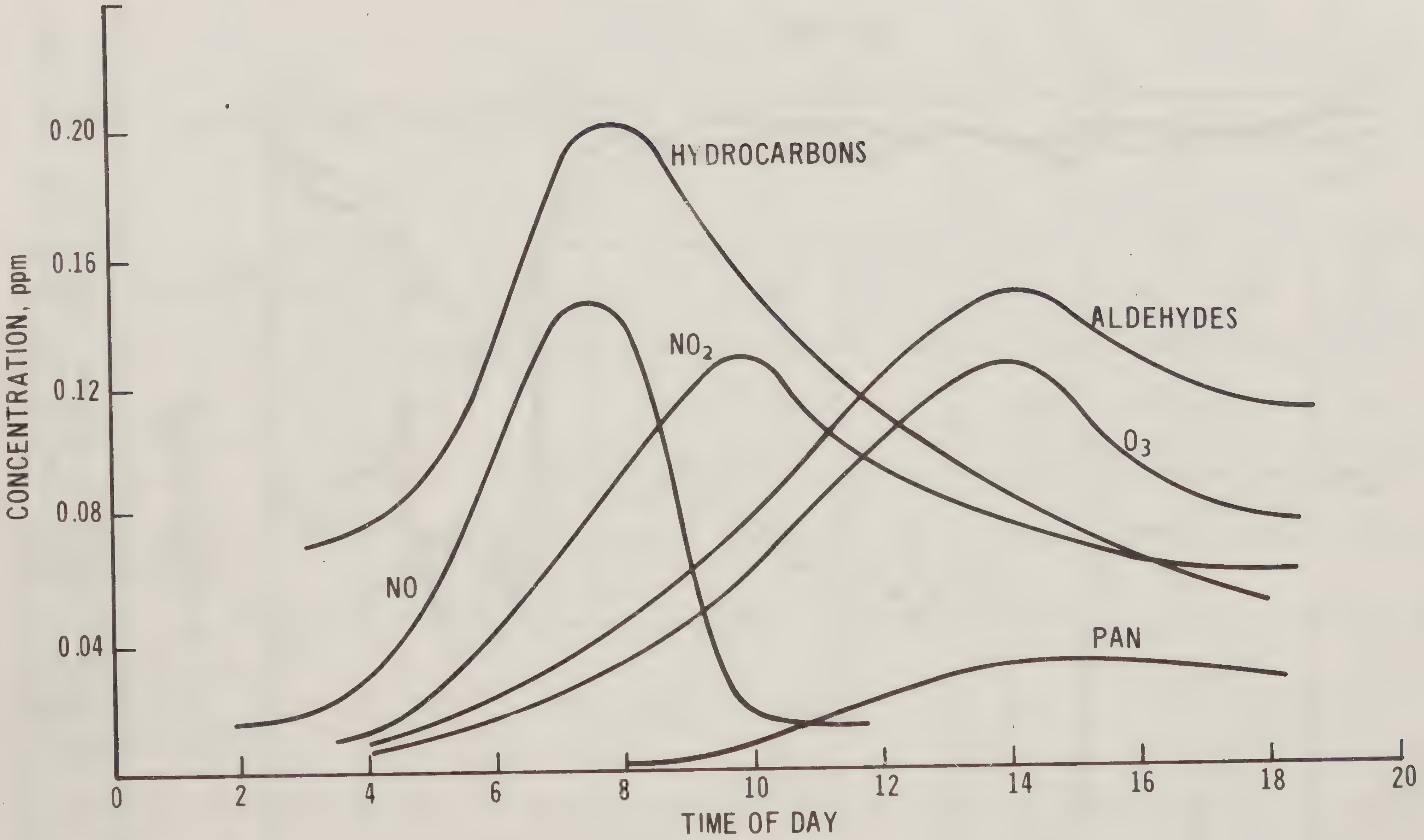

Fig. 2 Schematic representation of the photochemical smog cycle.

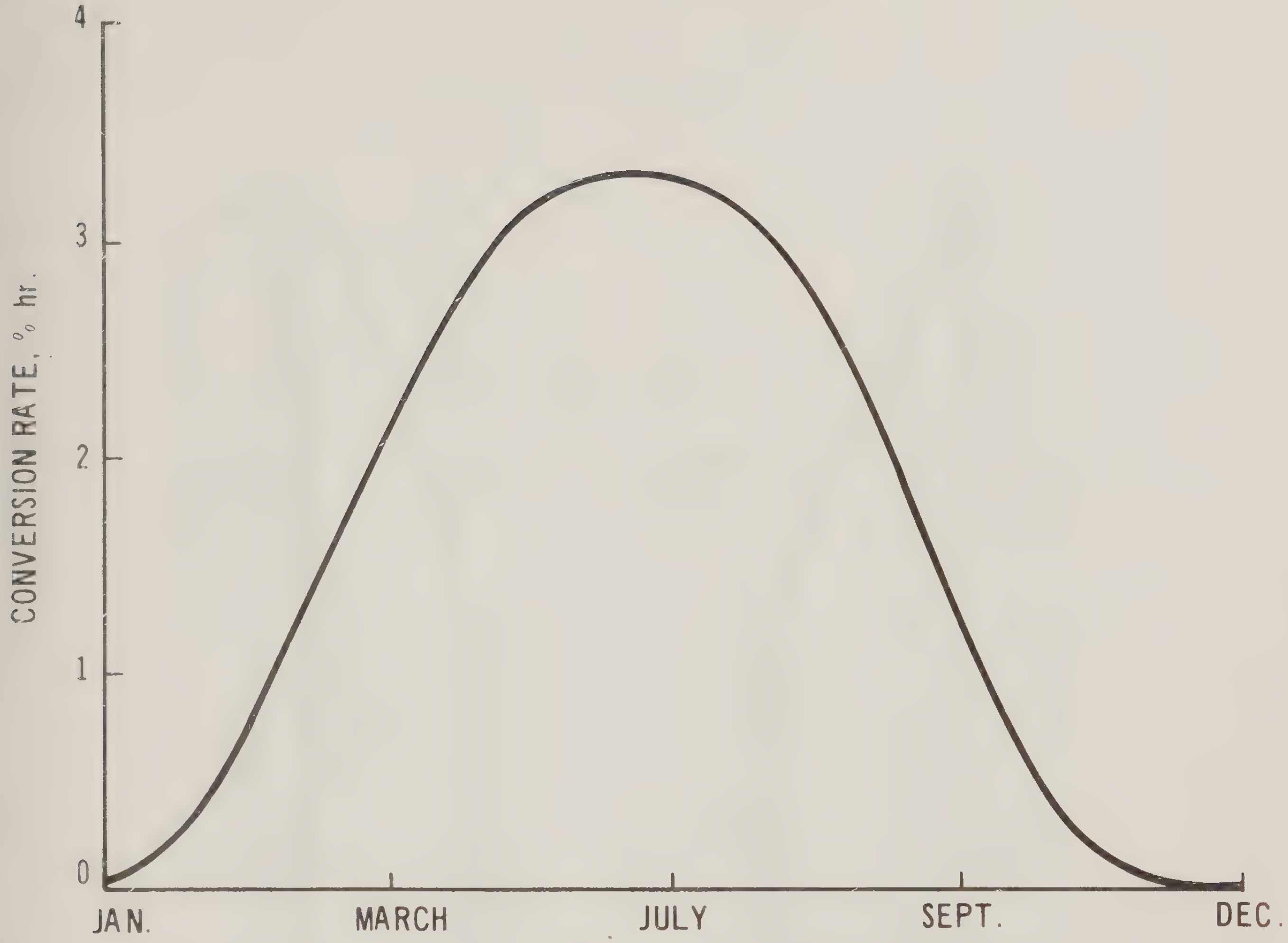

Fig. 3 Model prediction of the oxidation rate for SO_2 averaged over a 6 hour period about noon. Very little photochemical conversion is predicted for winter months in Northern latitudes.

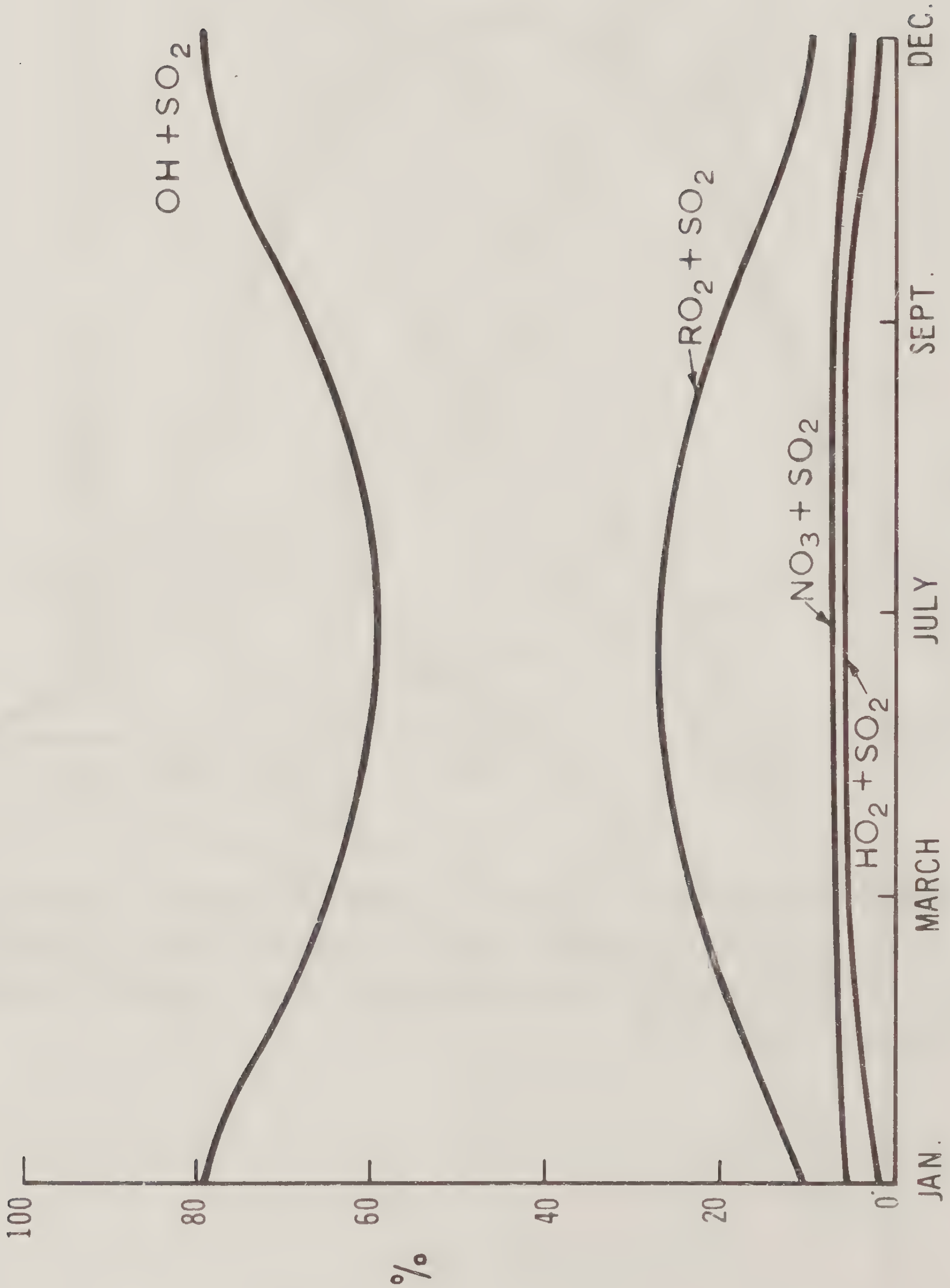

Fig. 4 Predicted relative contributions of reactions to SO_2 oxidation in a plume expanding into typical urban air.

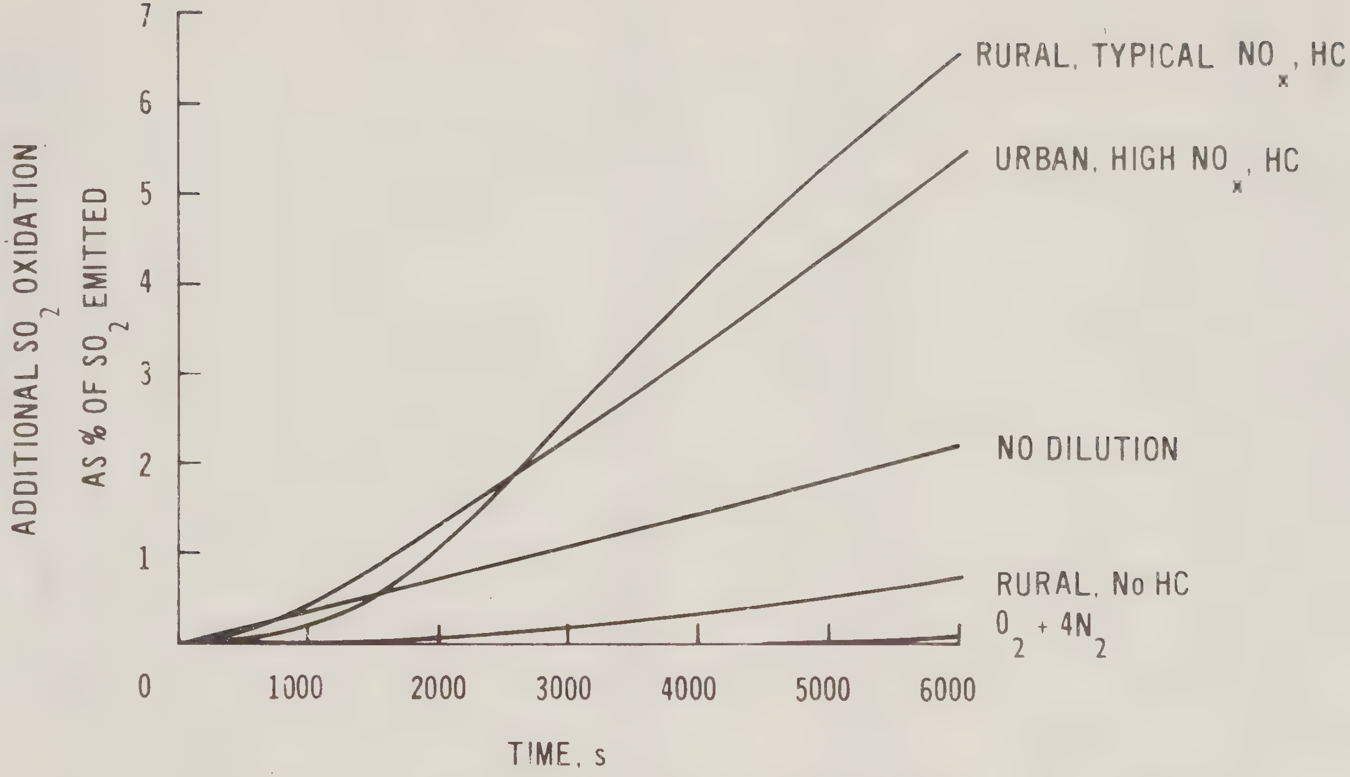

Fig. 5 Predicted oxidation rates for SO_2 in plumes expanding into ambient air of different compositions. The ambient air also contains SO_2 so that the rate plotted is the difference between the rates with and without the plume present.

NATIONAL SOCIETY FOR CLEAN AIR

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PLANNING OUR NUCLEAR ENERGY FUTURE

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1. INTRODUCTION

To provide an efficient and economic supply of electricity to our consumers as and when they want it is one of the statutory duties of the Central Electricity Generating Board. To continue doing so indefinitely into the future will require building some new power stations somewhere at some time to meet the growth of load and the retirement of the existing generation capacity. In planning new power stations each proposal is looked at as the next increment on an integrated national supply system. For these new power stations suitable sites must be known to give options from which to select the most suitable for whatever capacity and type of plant will be needed in a particular part of the country some 10 years ahead.

To meet an uncertain future it is necessary to adopt a robust strategy that will cover a number of different scenarios. Options must be planned and made viable to meet a variety of future needs.

The Generating Board is not committed to any one fuel or type of power station. Currently besides looking for sites for nuclear stations we are studying options for large and medium sized coal-fired stations including possible combined heat and power schemes, and for wind power generators. Most future power stations are expected to be nuclear but the others also have roles to play.

The capacity and general location of each new power station will usually be determined by the needs of the supply system. Ideal sites are hard to come by and so the optimum one within the general location where it is wanted, must be chosen by a careful balancing of the technical, economic and environmental effects of the sites available and the transmission work required both to connect these into the grid system and any necessary strengthening of the system itself.

2. STRATEGIC CONSIDERATIONS

This paper does not seek to make the case for nuclear power. It is however helpful to explain the background. It takes some 10 years to plan a new power station whether nuclear or coal-fired, to get the necessary authorisations, to build it and to bring it into operation. Power stations have effective lives of 30 to 40 years so in deciding the fuel to be used for new stations it is necessary to look well into the next century - further ahead than most other industrial enterprises consider. Without a substantial nuclear development the long term security of electricity supply could be jeopardised because of increasing pressures on fossil fuel supplies as well as the economic effects of the rising prices of fossil fuels as oil and gas become in short supply.

The Board's main primary fuel is coal which in 1980/81 accounted for some 80 million tonnes or about 80% of our total fuel requirement. Looking at coal as a national resource we took about two-thirds of the coal mined. Such heavy reliance on a single fuel does not offer a good basis for the long term security of electricity supplies and could pre-empt the use of coal which others may want for such purposes as making gas, chemical feedstock or even petrol substitute before the end of the century.

In Britain the existing nuclear power stations of the CEGB, SSEB and UKAEA, provide some 13% of the electricity supplied and this percentage should approach 22% by 1985 when three Advanced Gas Reactor (AGR) stations now under construction are completed. It is interesting to compare these percentages with those for some other countries which are given in Table 1. This country's proportion of nuclear generation is less than half that of the leaders in either year and our place in the table drops from sixth to seventh.

The other main fuel is residual oil which accounted for only 8% of energy for electricity generation in 1980/81. While the ability to burn more oil exists to do so would involve substantial costs. The relative costs of generation from the different fuels are shown in Table 2.

The strategic factors which affect the location of new nuclear stations are:

- where new generation is needed to provide economic supplies of electricity. In the 1990s plant with low generation costs is especially wanted in the south of the country to reduce the amounts of electricity generated at relatively expensive oil-fired stations. Siting there would also lessen the electricity imported from coal-fired or nuclear stations outside the area which involves energy losses in long distance transmission and perhaps the cost and visual intrusion of additional new transmission lines.

- the availability of the limited resources of water that can be provided inland, which makes it more logical to site most nuclear stations on the coast, putting inland most coal-fired stations with their lower lifetime water demand.

- the availability of sites as in this densely developed country the best industrial sites have already been utilised and there is a presumption against development in most rural areas. 25% of the coast of England and Wales has already been built on and over 60% of it is given statutory protection for amenity reasons. Even where suitable sites are found which do not conflict with one or other of these categories it is by no means sure that they will obtain public acceptance: certainly the prospective site at Druridge in Northumberland has not received universal acceptance.

- the need to make full use of existing resources both in partly developed sites and in transmission lines, to reduce the calls on the countryside which is already under pressure.

3. PLANNING PROCEDURES

Every year the Board considers plans for the extension of generation and transmission to meet future demands for electricity. These plans cover the long term fuel position, the security of electricity supplies, economics and when and where new power stations may be needed. As part of this the most suitable sites for the required new station must be considered and when necessary one is selected for consent application, and later, if consent and capital investment approval are obtained, the station is released for construction. Fig. 1 shows the timescale for power station planning.

So that a choice can be made it is essential to have a small pool of sites with known potential for accepting different types of power station in the different regions of the country. Identifying and proving these sites and carrying out power station planning is an iterative process.

Power station planning starts with periodic reviews of long term needs and updating of the potential of known sites. Where these do not match adequately, searches are made to see what other potential sites there are in particular geographic areas. These desk studies rely on published information and notifications from Government Departments and other statutory bodies such as the Countryside Commission and the Nature Conservancy Council of their knowledge of and interests in the area. Gathering and analysing this information may take about a year.

Detailed investigations are carried out when the area of search shows promising sites or when a prospective site becomes available e.g. through its release from use by Ministry of Defence. The various authorities, the landowner and occupiers are notified of the intention to investigate the sites and a public announcement is made before work starts. Another round of more detailed consultations takes place with bodies such as those concerned with planning, transport, water supply, fisheries and with environmental protection. From these contacts we add to our appreciation of what the local resources are and what local people are concerned about.

We can then determine the amount of effort to be put into studying what appears at this stage to be the significant technical and environmental issues which are considered in a later section. Experience of other power station development helps the selection of these issues and allows the efforts of the small number of skilled men to be concentrated where most needed.

The time to complete these studies, to make economic and environmental assessments of the alternatives and to make a balanced judgement on the outcome of these site investigations may take about two years.

It should be emphasised that the assessment of alternative sites is difficult and involves making judgements of widely differing subjects. Most technical issues can be evaluated in economic terms and the technical merits of alternatives can be reasonably accurately compared. However the environmental effects are less amenable to precise weighting. Noise levels can be predicted, and later measured and controlled, but what noise annoys one person may not worry another. Where a station building can be seen from can be calculated but whether this is seen as a dominant intrusion into a well known and loved view is a personal and subjective judgement. After comparing each factor for the alternative sites, all the technical and environmental factors have to be assessed together for each site for the different possible reactor types and capacities. Suppose one site would be £50M cheaper to develop than the next alternative and would have only a short connection to the transmission grid but would mean building on good farmland in an Area of Outstanding Natural Beauty.

The Board as the promoter of new projects has to make a decision, when a need is foreseen for a new station of specific type and capacity in a particular region. The Board must select what is believed to be the most appropriate site weighing what alternatives are available, what the transmission implications would be and the overall environmental effects.

When it is intended to make an application for consent the proposal is first put to a Government Interdepartmental Committee comprising representatives of those Ministries with possible interests so that their observations may be taken into account. Immediately before the application is made all the interested parties are notified and public announcements are made of the Board's decision.

The formal views of the planning authorities will be obtained and forwarded to the Secretary of State for Energy who will consider these and the views expressed by the public. Normally a public inquiry will be held and the Board will have the opportunity to present its case and the reasons for its decision. It is then up to the Secretary of State to judge whether the proposal is in the public interest.

The time taken from application to a decision by the Secretary of State has lengthened considerably. In 1956 getting consent for the first commercial nuclear station in the UK at Bradwell took six months. The application for the first Pressurised Water Reactor at Sizewell 'B' was made in January 1981, the Inquiry is expected to start in the latter part of 1982 with a decision hoped for in 1983.

While the main consents under the Electricity, Planning and Nuclear Installation Acts are being obtained, detailed design work and contract documentation is continued, as shown in Fig. 1. When consent and capital investment approval are given the main contracts are placed and as the precise plant details become known the various subsidiary consents are sought. These will have been discussed and cleared in principle during earlier negotiations. A list of the main legislation covering development of nuclear stations and from whom they must be obtained, is given in Table 3.

4. TECHNICAL AND ENVIRONMENTAL CONSIDERATIONS

From the earliest stage of an area of search both technical and environmental factors are considered together. It would, for example, be wrong for the Board to carry out expensive technical investigations only to find out later that the site had the highest amenity value. Sites are investigated in protected land such as Areas of Outstanding Natural Beauty only as the result of a deliberate informed choice when considered justified as a special case.

Because of the stringent technical requirements of modern power stations there are relatively few sites where the combination of physical resources can be found. The main technical factors are shown in Table 4.

Most of these are self explanatory but it may help an appreciation of what is involved to look at one in some detail:

- the 40 - 60 cubic metres/sec cooling water flow through the steam condensers after the turbines, is equivalent to about the volume of a single decker bus every second. This must come from an unfailing source of cold water, the shortest interruption would shut the plant down. The cooling water is warmed by about 10°C and must be discharged to a large body of water where its low grade heat can be dispersed before water is drawn back into the intake. Otherwise the recirculation of warmed water will raise the temperature in the condensers thereby lowering efficiency and could ultimately close the station down. Where large volumes of cold water are not available a close circuit cooling system with towers is employed to re-use the available water over and over again. However the re-cooled water temperature will be above the ambient and with the additional pumping some loss of efficiency is inevitable.

The phrase "environmental effects" is now used to cover a wide range of issues. It has been convenient to divide these into the ecological, the amenity and the socio-economic effects (Reference 2).

The ecological effects are those usually thought of as physical pollution affecting flora, fauna and human health. For nuclear stations there is no pollution from combustion products but atmospheric dilution is used for carefully controlled gaseous effluents mostly of low level radioactive noble gases such as Argon or Krypton. The cooling water abstraction discharges have already been mentioned. Surveys show the amount of fish drawn in has no commercial importance. The effect of warmed water discharges has been beneficial to fish particularly shell fish beds which have thrived round the outfall at Fawley in Hampshire.

Other ecological effects come from the physical occupation of land. As far as possible we avoid the best agricultural land and nature reserves, and try to ameliorate other such effects by layout.

In the current site investigations in the South West Peninsula the Nature Conservancy Council are carrying out ecological surveys round the sites so that they and the Board will have a common basis from which to assess the possible effects of prospective power stations. The Board are fortunate in having the results of long term research into such effects as well as data from monitoring operational stations (Reference 3).

Amenity is basically the preservation of conditions in the landscape that people want. A very difficult challenge as the reactor buildings are 60 metres (200 feet) high and cannot be hidden from all views: they will become new features in the landscape. What is done to make them acceptable is to give careful architectural treatment and careful grouping of buildings and structures. The preservation of existing trees and planting on and off site, on occasions land formation using surplus excavation material, can help to conserve existing views and create pleasant new landscapes.

Coastal siting often brings some conflict with amenity but one advantage is that direct cooling is possible whereas inland stations require several cooling towers

112 metres (375 feet) high or more. To evaluate the visual effects is largely a subjective judgement and is difficult. The present site investigations in Dorset illustrate the problem. One site is in the AONB just inland of Chesil Beach, and could be direct cooled, with the buildings partially screened by locating them in a shallow valley. An alternative site is well inland adjacent to the UKAEA at Winfrith which is outside the AONB but its cooling towers would be visible from wide areas of prized countryside.

Landscape consultants and architects are employed to help with the assessment of landscape quality, the scale of possible visual effects and to get the best amenity results from new buildings.

Much interest has been taken recently in the socio-economic effects of major industrial projects. Independent research studies by Oxford Polytechnic have been funded by the Generating Board since 1976 to look into the various ways in which building and operating power stations affect the local communities (Reference 4). The results provide facts which are a guide to help future planning as well as testing hypotheses and suggesting methods of predicting effects.

The studies show that power stations in rural areas had mixed socio-economic effects - some good, some bad, none dramatic and overall the balance was seen by local people as beneficial. The most important effect was on the labour market with employment opportunities being the main benefit, and the more noticeable implications being the demands on local services such as housing and schools, and the effect on physical developments such as restrictions on building near nuclear stations both to safeguard the public and to prevent risk of hazards to the station.

5. CONSULTATION AND COMMUNICATION

It is worth giving a special section to this subject because if a degree of public acceptance to nuclear power is not obtained the viability of continued development is in question.

As mentioned earlier both before and during the site investigations the Board seek advice and information from Government Departments, statutory bodies and local authorities. The pattern of planning consultations are shown in Fig. 2. As soon as site investigations are proposed public announcements are made and much is done to explain to local authorities and to local people to put their views and make suggestions on the extent of the investigation in the hope that even if they do not feel able to accept the proposal at least they will know their concerns have been recognised and given consideration. The amount of effort put into this work is considerable and can be very time-consuming and demanding of manpower. For example, in February 1980 the Generating Board announced the investigation of five sites for prospective nuclear power stations in Cornwall and Dorset. In the first four months there were meetings and discussions with both officers and Councillors of two County Councils, ten District Councils and various Parish Councils. Typical subjects for consultation at this and at later stages are shown in Table 5. There were discussions also with five Government Departments, two Water Authorities, two Police Authorities, the Health and Safety Executive, the Nature Conservancy Council, the Countryside Commission, the National Trust, the National Farmers Union, the Country Landowners Association and contacts with a variety of other individuals and bodies ranging from five MPs to the OECD in Paris. In the same time some 40,000 leaflets were distributed explaining why we were looking for sites in the South West. This was followed by a travelling exhibition staffed by the Board which went to eleven locations for a total of 25 days. In addition a number of us gave interviews to both BBC and IBA television and radio.

When we make an application for consent much of this consultation and communication is repeated with the same people, though this time more detail can be given about what is specifically proposed. For example, when the application was made for the first PWR at Sizewell some

1500 copies of a project statement were distributed and this was followed by two leaflets on the PWR and on the choice of Sizewell and together 100,000 copies were circulated to local people. A travelling exhibition manned by the staff involved went to seven locations for a total of 13 days. So far there have been three public meetings arranged by the local authority at which the Board's officers concerned have answered questions. There have been two seminars for local authority members and officers. To cope with a very large programme of responses from local societies and opposition groups the Board has a full-time technical liaison officer located at Sizewell power station.

In addition to all this effort on public communication, the normal negotiations for consents with the local authorities and statutory bodies were going on together with arrangements for the provisions of various services, as well as the preparations for the build-up to a major public inquiry on Sizewell 'B'.

While a power station is being constructed the Board will keep in close contact with the local authorities and others to ensure that there is a channel for information and for complaints to be received and dealt with promptly. Before any nuclear station starts operating the Board must set up with the local authorities extensions to their Emergency Plans to allow for the protection of local people in the possible, though remote, chance of a release of radioactive material. Also a Local Liaison Committee will be set up with members and officers from local authorities, representatives of local organisations.

6. CONCLUSIONS

1. The Board's nuclear strategy aims at making available technically proven and economic plant. Further nuclear station proposals will be the subject of specific decisions on the overall need, on the foreseen time and location.

2. As part of this enabling strategy sites must be

identified and proved ahead of need to give options for flexible responses to an uncertain future.

3. Planning procedures consider technical and environmental issues in parallel from the earliest studies. A major challenge is to make balanced assessments of many differing factors some of which can be evaluated in economic terms with others based largely on subjective judgements.

4. Consultations with local authorities as representing the public and direct communication with local people is essential. Greater efforts are being made to give better understanding to maintain local acceptance of nuclear stations.

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TABLE 1

Nuclear Power as % of Total Electricity Production

	1980	1985
Belgium	21.3	52.5
Britain	13.1	21.6
France	23.6	58.7
Japan	13.8	19.3
Spain	6.2	35.8
Sweden	27.0	33.3
Switzerland	27.2	29.6
West Germany	11.1	23.2

Source

OECD Provisional Estimates

TABLE 2

Relative Costs of Generation

	Nuclear		Coal	Oil
	Magnox	AGR		
1980/81	100	88	112	159
1979/80	100	104	120	148
1978/79	100	-	119	121

Annual Variations reflect changes in fuel prices and in electricity output

TABLE 3

Main Legislation Covering Development of Power Stations

Electric Lighting Act 1909	Consent of Secretary of State for Energy subject to financial sanction, to develop a site for a station
Town and Country Planning Act 1971	Planning direction of Secretary of State for Energy covering details of buildings, land use, etc.
Nuclear Installations Act 1965	Nuclear Site Licence from Health and Safety Executive to permit use of site for nuclear reactor
Radioactive Substances Act 1960	Approval of Secretary of State for the Environment and Minister of Agriculture, Fisheries and Food to store or move radioactive waste.
Dumping at Sea Act 1974	Licence from Ministry of Agriculture, Fisheries and Food to place materials (includes structures like jetties, cooling water head-works) in UK waters below high water mark.
Coast Protection Act 1949	Consent of Secretary of State for Trade to works below high water mark.
Water Resources Act 1963	Licence from relevant Water Authority to abstract cooling water.
Rivers Prevention of Pollution Acts 1951/61	Consent of relevant Water Authority to discharge cooling water and trade effluent.

Land Drainage (Amendment) Act 1976	Consent of relevant Water Authority to changes to land drainage.
Control of Pollution Act 1974	Licence from County or District Council for waste disposal. Consents from relevant Local Authority relating to control of noise or other pollution matters.

TABLE 4

Technical Factors Considered for a 1300 MW Nuclear Station

Cooling Water	
(a) Direct Cooled	40-60 cumecs (35-50 million gallons/hour)
(b) Tower Cooled	2-3 cumecs (40-60 million gallons/day) abstracted, about 0.5 to 0.75 cumecs evaporated
Land	
(a) Site Area	60 hectares (150 acres)
(b) Geology	Ground must support very heavy loads around 100,000 tonnes, with virtually no differential settlement
Nuclear Site Criteria	Sufficiently remote from centres of population and from potential hazards to comply with licensing authority's requirements
Transmission	Line routes for 400 kV connection to the transmission grid system
Access	
(a) Construction Materials and Fill	1 to 2 million tonnes mostly in three years
(b) Abnormal Loads	About 50, some around 500 tonnes

TABLE 5

TYPICAL SUBJECTS FOR CONSULTATION WITH STATUTORY BODIES

During Power Station Site Investigations

- Structure and Local Plan policies and proposals
- Protected areas, historic buildings, etc.
- Population/employment trends
- Agricultural value
- Mineral resources
- Recreation/Tourism
- Environmental effects
- Access from site to main roads, railways and ports
- Existing traffic and potential hazards
- Resources for cooling and portable water supplies
- Water quality/Pollution control
- Sewerage
- Fisheries/Watersports
- Flood levels
- Coast protection
- Public communication/Local concern

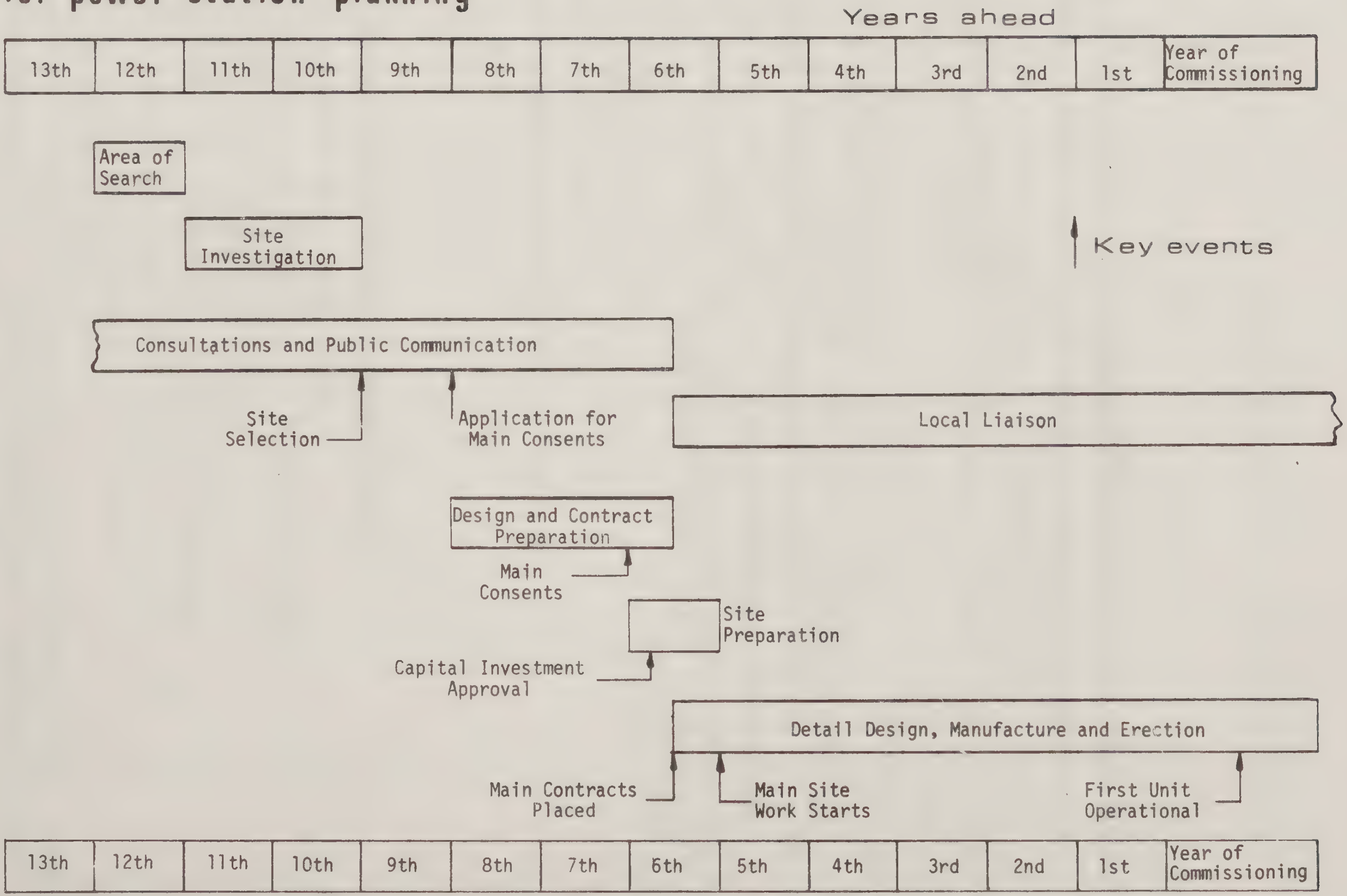
During Consent and Station Development

- Proposed site area and level
- Orientation and location of main buildings
- Architecture and Landscaping
- Access routes and improvements
- Safeguards from traffic and other hazards
- Transmission line routes
- Cooling water abstraction and return
- Potable water supply
- Location of offsite works e.g. caravan camps, rail head, mineral sources, filling material and dumping areas
- Environmental effects and protection measures
- Public communication

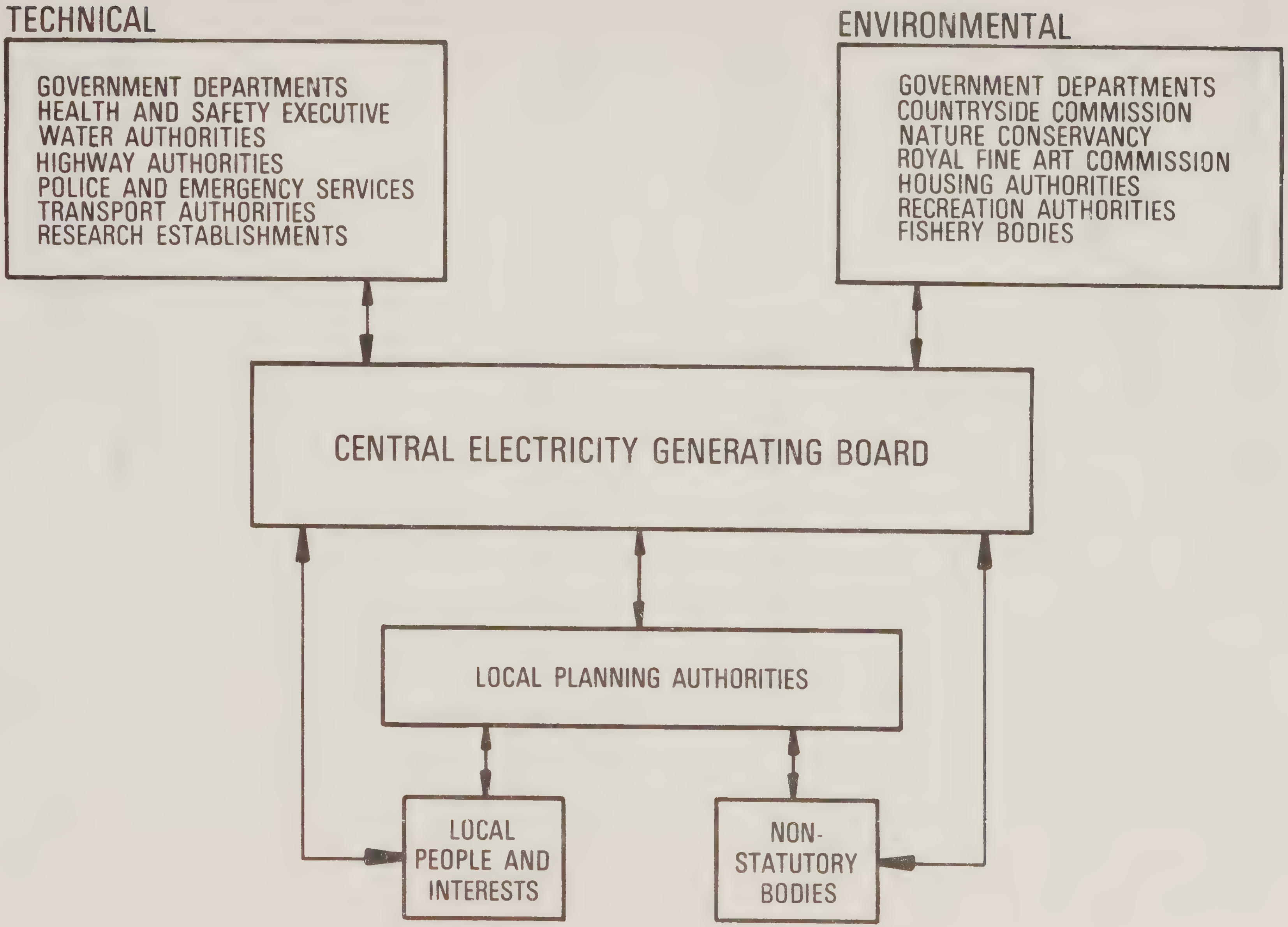
During Construction and Operation

Implementation of conditions on architecture, landscaping and planning matters
Local employment/resource development
Housing for staff, provision of education and other services
Environmental health protection
Provision of water supplies and sewerage, improved flood and coast protection, land drainage
Provision/protection of recreation and other facilities for public enjoyment
Emergency planning
Development Control/Safeguarding
Local Liaison

Typical timescale for power station planning



POWER STATION PLANNING CONSULTATIONS



NATIONAL SOCIETY FOR CLEAN AIR

48th ANNUAL CONFERENCE
5 - 8 OCTOBER 1981
BRIGHTON

NUCLEAR POWER: THE PROBLEMS OF PUBLIC ACCEPTABILITY

by

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1. Opposition to civil nuclear power in UK frequently characterised, officially, as irrational and captious. A dangerous misconception. (CPRE is concerned about environmental impact of nuclear facilities, as about many other major developments in rural areas). So what are the factors creating problems of public acceptance for nuclear power in the United Kingdom?

2. First, anxieties about the need for, and environmental impact of, new nuclear facilities:

(a) Scepticism about need and economics - intensified by recent reports of the Select Committee on Science and Technology and Monopolies Commission. Supplemented by growing understanding and documentation of the potentialities of energy conservation, as a means of reducing the national rate of growth of energy demand. Also, lower energy demand forecasts as a result of continuing economic recession. These have implications for electricity prices and consequently for future anticipated demand growth. Further economic factors include consistent capital cost overruns in installation of major new plant by the CEGB. Such factors combine to make local and national bodies (including local authorities) sceptical of claims by CEGB for need for new nuclear plant in particular cases. In a sense, this argument is directed less at the CEGB than at the Government. The implication is that alternative policies and patterns of capital investment (for example more local energy supply, much more systematic conservation policies, creation of a statutory energy conservation agency with powers to match those of the major energy suppliers) could produce long run patterns of energy consumption in Britain which would further undermine the need for major future investments in civil nuclear power.

(b) Safety issues - interlock with economic considerations. As safety standards and requirements become more exacting, capital costs increase. American studies (Komanoff etc.) show this relationship very clearly. There is likely to be increasing public anxiety about the way in which such trade-offs between economics and safety are made. What is more there are of course prima facie anxieties about, particularly PWR and FBR safety. It is the scale of a possible accident, however improbable, that gives rise to the concern - a factor which risk analysis appears not to be designed to address.

(c) High-level waste and intermediate-level waste disposal problems are severe and growing. Without their resolution in politically acceptable ways, nuclear opposition unlikely to diminish.

(d) Local environmental factors - particularly amenity and siting issues - likely to become more and more significant, as search for suitable sites moves to increasingly valued coastal and estuarial sites. The problems encountered by CEGB in current site investigations give hints of what may lie ahead. Increasing opposition likely on local environmental grounds from bodies not opposed to nuclear power per se.

3. Above factors will arise in relation to specific new proposals for nuclear plant. However there are further underlying anxieties which tend to shape the intensity with which new proposals will be examined and challenged. These can be encompassed within the question 'Where is this leading?'. Thus:

(a) Industrial and institutional logic of nuclear development - very long lead times, high technology, highly capital intensive, and needing certainty of long range planning - implies that individual nuclear power station proposals are inevitably embedded in larger programmes and plans. Nuclear investment only becomes attractive industrially if a steady ordering programme of nuclear stations can be guaranteed to manufacturers, suppliers etc. This clashes with public expectations that the results of individual public inquiries will not be pre-determined. In broadly comparable circumstances vis a vis the motorways programme in the mid-1970s, objectors (not CPRE) resorted to civil disobedience - because they were convinced that inquiry procedures were biased simply to facilitate government's wish to complete a largely pre-planned motorway programme. A similar response now seems to be developing towards nuclear power station proposals - e.g. civil disobedience at Luxulyan, Cornwall, where CEGB has gone to court in attempts to clear the site for investigations.

(b) The electricity supply and nuclear industries - as well as the Department of Energy itself - see development of thermal nuclear power as precursor to widespread introduction of the fast breeder reactor. 'Without fast reactors nuclear power can make a useful but comparatively short lived contribution to the world's energy supply. With the fast reactor nuclear power becomes the most important world energy source of the future' (Dr. Walter Marshall, Chairman of UKAEA, 10.9.81). Given this link in the official mind, members of the public concerned about a national commitment to the plutonium fuel cycle (fast reactors) will object to thermal reactor expansion also, attempting to discourage creation of infrastructure which will in turn require fast reactors.

(c) Plutonium fuel cycle has major social and civil liberties implications, which will increasingly make it a political issue. This will tend to draw new groups - for example nuclear disarmament bodies - into arguments about thermal nuclear stations.

4. All of these factors will be in the public arena, because all new nuclear proposals will be made the subject of public inquiries. There is widespread public expectation of involvement in local planning issues and it is hardly conceivable that factors of the kind outlined above can be excluded from the discussion of individual new proposals. The apparent inequity of imposing controversial and intrusive supply facilities on environmentally valued sites, when there is minimal local benefit to be derived, will also become issues of substance.

5. This suggests acute difficulties ahead for implementation of a major nuclear programme in UK. Dynamics of the public inquiry system will work to ensure that the local objectors and people with national concerns of the kind outlined particularly in paragraphs 2 and 3 above will find their way into disputes at individual sites. In these circumstances it's arguable that problems of public acceptability entailed by nuclear power ought to lead the Department of Energy to promote urgently other non-nuclear solutions to Britain's long-term energy problems.

NATIONAL SOCIETY FOR CLEAN AIR

48TH ANNUAL CONFERENCE
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POLLUTION CONTROL
PART II
DISCUSSIONS

136 NORTH STREET
BRIGHTON BN1 1RG, ENGLAND

48th ANNUAL CLEAN AIR CONFERENCE,
BRIGHTON, 5-8 October 1981
PART II - REPORT OF DISCUSSIONS

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OPENING SESSION

WELCOMING ADDRESS by
Mr. H. Giblin, Chairman of the National Society
for Clean Air

Madam President, Mr. Mayor, My Lord, Past Presidents, honoured guests, Ladies and Gentlemen. It is my privilege and pleasure to welcome you to this, the 48th Conference of the National Society for Clean Air. I am really gratified to see so many people here tonight and I am sure that all of you will be equally as pleased to know that our attendance this year is the same as it was last year. When one considers the economic climate, this is quite an achievement because many other conferences are suffering from lack of numbers. I can only assume that this is because of your interest in the work of the Society. I believe, I honestly believe, that we have a long way to go yet, that the job is nowhere near completed; in fact we have only reached the watershed of new endeavours, new ideas and new approaches to the whole question of air pollution and noise abatement. I also look upon your attendance here as an indication that you also realise that we have more work to do, and that, as I say, we have only just started.

I am sure that you will find the Conference interesting and rewarding. There are a tremendous number of good papers covering a very wide range of subjects - pollution, noise, toxic wastes - and I think a good one at the end of the Conference, where we discuss Britain's Nuclear Future; it will I hope be quite a good, controversial discussion that all of you will join in. We have invited people from the Brighton Polytechnic and the University of Sussex to join us, so we are hoping that it will provide a good end to the week. I hope that you find the Conference entertaining because I believe that these Conferences should be entertaining. We should enjoy ourselves, as much as learning from them as I think part of these Conferences is having a pint at the pub round the corner, meeting old friends, talking over new ideas, relating things that you have learned that can be a help to someone else. I hope this happens and I hope that I might get the opportunity of joining you - in one of these pubs round the corner.

I do not think that finding entertainment in Brighton is very difficult. Brighton is a unique place, with a mixture of Old World Charm and modern ideas. The Old World charm is provided by The Lanes, the antique shops, the Pavilion. The new ideas are epitomised by the Marina, which was a wonderful approach by Brighton, and there is that beach down the road! Regrettably, the temperature is too low to allow of any entertainment down there. I would not advise any of you to participate but, if you do, let me know and I will come down and have a look. And then, of course, there is this wonderful Conference Centre. It has already seen, as we know, some good entertaining conferences. I was surprised when I came in and looked in the big building next door that the roof was still on, but it is, and the serial (Labour Party Annual Conference) will be continued I believe next year in Blackpool. I always like coming to Brighton. When I was younger and one talked about Brighton, it was a place with a little bit of mystique about it. You came down to Brighton and it was different. It is still different, as far as I am concerned.

To be a Councillor is a hard job. Their interests cover such a wide range of subjects and I know they have worked hard; but to be the Mayor of a town like Brighton must be difficult indeed, particularly when you realise that this year alone the Mayor will have attended over 1,200 functions, many of them being conferences like this. I would like to thank the Mayor and Mayoress who have given up their time to join us tonight. I would also like to thank the Worshipful the Mayor of Brighton, Councillor Joseph Wakefield, for consenting to open our conference.

ADDRESS by
The Earl of Avon, House of Lords Spokesman on the Environment, Transport and the Arts

I am extremely pleased to be here this evening at the opening of your Annual Conference, particularly as this year marks the 25th anniversary of the first Clean Air Act. I hope you will not feel it impertinent if I lay claim to some small family credit for that initiative in 1956. My father, then Prime Minister, was a convinced supporter of the Clean Air Act.

We can all be justifiably proud of the improvements in air quality made in the last quarter of a century, and members of this Society, both in a corporate, and individual way, have been leading contributors to those improvements. There will be lasting benefits to the health and cleanliness of this country, and now that the worst conditions of smog and smoke are becoming little more than a fading memory, it is tempting for people to think that nothing remains to be done. This as you know is not the case. Not only must we continue with the visible improvements but we must safeguard the progress that we have already made.

May I reflect a little on how we arrived at the present situation.

It may seem strange now to be marking a 25th anniversary when, as was remarked in 1973, we should then have been celebrating the 700th anniversary of the beginning of the struggle against air pollution. But the fact is that despite repeated attempts down the centuries to deal with various problems of air pollution it is only now that we are, for instance, in a position to mark a substantial period of real success in dealing with the widespread problem of smoke.

The great period of industrialisation and urbanisation in the 19th Century considerably aggravated the problems of air pollution. These did not escape the notice of the great public health reformers and certainly in relation to industrial emissions the basic solutions in terms of legislation and a philosophy of control were devised then. But even though the Public Health Acts helped it was not until the end of the century that the more widespread problem of coal smoke began to be effectively tackled. Your forerunners in the Coal Smoke Abatement Society, and later the Smoke Abatement League were instrumental in beginning the detailed process of monitoring and analysis that provided a sound foundation on which legislative progress could be made. In the event, although committees met and pieces of legislation were passed it took the dramatic events of 1952 in London to bring home to Parliament the need for legislation on a national scale.

Even when the need is so clear, legislation is rarely an easy or quick process but by 1956 the Clean Air Act was passed. It is primarily through the progressive designation of smoke control areas under that Act that we have secured the substantially clean air we know today.

Of course we were comparatively lucky in that a range of technological changes took place at the same time; the conversion from steam to diesel and electric locomotives on the railways, the trend towards using oil, gas and electricity for heating, and improved technology for the combustion of solid fuels, all these have lightened the burden of bringing about the necessary changes. But some of these trends could turn against us; North Sea gas will not be with us forever and in determining the probable energy balance for the future, pollution considerations can sometimes be overtaken by wider economic forces.

So much for the demonstrable success of the past. What of the future? In contrast to 1956 we are now more conscious of the "environment"; indeed we now have a substantial Department named after it, and Michael Heseltine and all my colleagues there are keen to see it make a positive contribution to improving all aspects of the environment. The European Community is now an important feature in our deliberations on environmental matters. We are, to everyone's benefit, adopting common policies over wide areas of the environment including the control of air pollution.

The Government believes that the sensible way to do this is to concentrate on devising standards for air quality and, as you are well aware, we have recently agreed the first directive specifically setting up air quality standards - in this case for smoke and sulphur dioxide. This gives the Government and local authorities a strategic framework within which to consider the progress we have made in improving air quality and to identify those areas where further improvements may be necessary. Some more smoke control is needed in some areas; in others we may need to look particularly at sulphur dioxide emissions and perhaps control these through regulations on the sulphur content of the fuel oil.

We are looking forward to the cooperation of local authorities in bringing everywhere up to the standards required by the Directive as quickly as we can, given the available resources.

Another area of considerable interest recently is pollution from lead. The problem here stretches well beyond air pollution alone and Professor Lawther, as you know, one of your distinguished past presidents of the Society, conducted a most helpful review for us on all aspects of environmental lead and health.

The Government is proceeding to implement most of the recommendations made by Professor Lawther's committee including in particular a reduction in the lead content of petrol. This will enable the UK to comply generally with the proposed air quality standard for lead. The UK, as President for the time being in the Community is pressing forward with the proposal for a directive incorporating that standard.

One priority for the immediate future must be to ensure that there is no return to the dreadful air pollution of the past. This means taking careful note of what the Commission on Energy and the Environment have had to tell us and seeking to ensure that our legislation is adequate to deal with the problems that are arising as well as with the problems for which it was originally designed. If there should be need to take specific action on other pollutants we will increasingly be adopting an air quality approach although some careful thought is needed to ensure that we continue to reap the benefits that the pragmatic improvements from "the best practicable means" approach has brought us.

In trying to look further forward to what the next 25 years will bring, it is probably fair to assume that there will not be the same degree of visible progress as over the last quarter century. I stress "visible". I am highly conscious that I am speaking not only to the converted but to the expert and I think one sometimes needs to reflect on what the average man in the street thinks of as air pollution. Generally it is things that he can see, like dirty black smoke from an industrial site, or else things that affect him in some tangible way, like smells, and these will still have to be dealt with.

The more sophisticated chemical pollutants with which both you and my Department are more concerned do not receive quite the same type of attention; although the interest in lead suggests that the general public is increasingly sophisticated and able to express a desire for action on these more complex topics.

In considering these more subtle problems of the future the Government sees the National Society for Clean Air continuing to play the important role it has played in the past.

Government has, over the last 25 years, recognised the need to be closely in touch with outside expert opinion on all matters concerned with air pollution. This has been done in a variety of ways but running through all of them you will find one consistent thread; advice from, and representations by, members of the National Society. This advice has always been particularly valued because it comes from a body with an extraordinary range of interest which extends from local authority representatives through the professional environmental health interests, covers industry also and includes scientists, academics and of course the public at large.

We value the continuity of effort over the years, the consistency and integrity of the Society's purpose and its approach that reflects the need to maintain a carefully considered balance between reducing pollution and the economic health of industrial and commercial activities. We welcome too the continuing broadening of the Society's interests beyond air pollution to cover noise and other matters.

To describe people as a "Pressure group" sometimes sounds almost like an insult in government circles; but I can assure you the Society is never thought of as other than a helpful organisation.

No doubt you will always be applying pressure to us in one way or another - that is part of your role in life - but I hope you will feel, as we do, that there is a constructive aspect to such a relationship in which we can seek views from you about the issues of the moment and know that the views expressed by the Society are the results of debates in a forum that spans all the relevant interests.

Everyone here can look back on the achievements of the past 25 years in creating cleaner air as an example of the constructive cooperation between all those involved that is the best way to tackle such problems. I am sure we can look forward to the continuation of that cooperation in the future.

RESPONSE by the Chairman, Mr. H. Giblin

I was delighted to hear your reference to the work of the Society and its relationship with the Department of the Environment. I think that we have reached the stage where the Clean Air Act and pollution control is at a watershed. It was easy in 1956 to generate interest. People could see the problem; it was all around them, but today it is different. We have got to start to regenerate interest amongst many people. The young today have no idea of what conditions were 30 years ago. And many young councillors do not realise the amount of work that their predecessors put into introducing smoke control in their towns and their cities and the amount of money that has already been spent on clean air.

What worries me to a certain extent is that we could, if we are not careful, go back. At an earlier meeting, a previous chairman mentioned that some local authorities had put forward revocation orders. This, of course, could be fatal. I know that at the time, if those orders had been revoked, there were other local authorities waiting to submit their revocation orders. There is also a tendency for an increase in the use of unauthorised fuels. That is why I feel that we have really got to look at the whole situation and to say, can we sit back, or must we put more effort into what we are attempting to do? The Planning and Land Act now allows a local authority to revoke orders it has made. In my opinion this could be dangerous. If you take the case of a local authority with some orders already in operation which makes another one and then revokes it for whatever reason you like, political or otherwise, where do the other smoke control areas in the town stand? Would they still have to conform or has the local authority given away its authority?

I think the new EEC Directive on sulphur dioxide and suspended particulates has come at an opportune time; it has given us new targets, new approaches, something to aim at. I know that when the Department of Environment drew up the list of local authorities who were very close to the limit values it spread a pretty wide net. Some of the local authorities were on the fringe but, if the meshes of that net had been a little smaller, through possibly a more extensive monitoring system, some local authorities may have not fallen through that net and may have been on the list. I would not like to think that local authorities not on the list can assume that they have nothing to worry about because, as Lord Avon mentioned, there are pollutants other than sulphur and smoke - subtle forms of pollution - that all of us have got to keep an eye on.

We have other problems of course, notably noise - which is coming more and more within the scope of the Society. It is an insidious thing which grows on you. You may not notice it at first, but physically and mentally it can affect you. As I mentioned previously, I would like to see the Society take more interest in this subject and bring it within its scope. You may have noticed the changes which are to take place in the work of the Society following the introduction of its paper, 'The Way Ahead'. The Society has also examined its promotional activities, looking at all aspects, both to promote the Society and to promote clean air. These changes we shall see taking shape within the next 12 months or 2 years. And, at this stage, I would like to say how much I appreciate, and the Society should appreciate, the work of two previous chairmen - Howard Fuller who instigated the Way Ahead programme, and John Clarke, who saw it come into being through his committee last year. Both of them did a wonderful job.

All of us were disappointed to see the abolition of the Clean Air Council and the Noise Advisory Council. Yet we still need a focal point; we need a centre that can gather information; we need a "springboard" to launch new ideas and new points of view - an organisation to stimulate activity, both in clean air and noise. And the Society, in my opinion, is the responsible organisation that can do this. We need the support of the DOE in all these things and, I hope, financially as well. The Society could carry out commissions for the DOE on a fee-paying basis; but what we really need is its full support in all our activities.

We also, of course, want the support of local authorities; we want the support of industry and we want the support of individuals. If we can obtain this, then possibly the Society can in due course achieve the aims and objectives it set itself some 52 years ago.

Now it is my very great pleasure to introduce to you our new President, Naomi McIntosh, the first Lady President of the Society since 1949. Some of you may say, "Shame!", and I rather agree with you. It has been too long since we had a lady President. When you read through the Society's conference Handbook and the Chairman's notes and consider her wide range of interests you might think that you are reading about three people, not one. And all of these interests require papers to be read and to be studied, meetings to attend. As a consequence I think we are indeed fortunate and honoured that she did agree to accept the nomination to become our President. I read that one of her great interests is education, student education and adult education. I am sure that this will stand her in good stead in her new post as Senior Commissioning Editor for the new Channel 4 TV company. I wish her, and I am sure that on your behalf I can wish her, success in this new post. But it is as a member of the Commission of Energy and Environment that I think she would like to base her Presidential Address tonight. Ladies and Gentlemen, Naomi McIntosh.

PRESIDENTIAL ADDRESS

Naomi E. S. McIntosh

I do not know quite how I was picked for this job. When I asked, I was told that, firstly, the Society's Council thought they needed a woman; secondly, they had looked through "Who's Who"! I must simply say that I am immensely honoured to have been asked. I hope that I can do a useful job for two years. If I do something about half as useful as Sir Derek Ezra has been doing for the last two years, then perhaps that will help the Society a bit.

A crack has already been made about the fact that this building is still up. It does seem to me that it is proper to follow all the "hot air"* last week with some "clean air" this week, and that we would all benefit from that. I am also glad that you decided long ago to prohibit smoking in all Conference sessions. My personal campaign is against being forced to inhale other people's smoke. This is commonly described nowadays as "passive smoking". I think that euphemism is far too polite: their freedom is my punishment and I do not care for it. I let my view show at one point to one of my early Gas Consumer Council's meetings when, at the end of lunch, somebody said, "Do you mind if we smoke?" and I, quite without thinking because I was late and tired, said, "If you insist on polluting my air space, of course, do smoke!" You can imagine the atmosphere. So, I throw out to you as a minor challenge, that we non-smokers could do with some sort of badge. Obviously it cannot be quite as rude or long-winded as, "You have no right to pollute my air space" but something like that, because I do think that it is extremely important. Maybe we would settle for "Keep our air clean".

The title of this Society has the immense virtue, for me, of using clear and simple English. Clean air is something that everybody can understand. I tried out the title on my sons, who were a bit baffled about why I was coming down here; I explained about the NSCA and they still looked at me a bit blankly. My sons are 17, 19 and 22, and the 19-year old said, "Don't know. Don't know what it means". I went into it in some detail; we talked about smoke from coal fires and went on to cars and he said, "But you drive", at which point I came down on the train. However, he was right; in the world in which this Society operates and in which we all live, we all want to have our cake and eat it.

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*The Labour Party Conference

My son's remark caused me to think - and Lord Avon commented on this - about that time in the 50s with that awful fog. I was at university then; I was about 19, the age my son is now. In London, at that stage, we lived for several days with that smog. It was brown and dark and you could not see. Of course you could not drive, but I did not drive then, I cycled. I lived in Highgate, so I cycled down to Regents Park, and on to LSE in the Strand. I vividly remember a day in which I had got my bike down to the LSE but it was not possible to ride it in the fog, and I pushed my bike all the way up from the Strand, through Camden Town and on to Hampstead. As I got about half way along, I discovered that a queue of cars was following me because they could see me and I could see the pavement. But, without me, they could not have driven. We even had to go around with smog masks on! But the most important aspect of that time for me is that my father was extremely ill every single winter, with bronchitis and pneumonia - so ill that I thought of my father as a really old and ill man. I remembered this as I came down on the train today and calculated our ages, then I realised that my father was then a year younger than I am now.

The point of that story is that my father now is alive and well, never ill in the winter, and is working full-time at the age of 75, running the legal pressure group called Justice, absolutely refusing to give up and retire. At that stage, we never thought he would survive and he has survived simply because of those changes that were made in 1956. Thinking about that made me realise about memory, about history, about education, about what was going on with our children, and the task that there now is to be done. So my second message is that we must not and cannot be complacent about any of this.

Those of us who were girls in the 1950s used to wear white petticoats. Black underwear did not exist at that point. I suspect it did, but it was considered as being for tarts! As Lord Robens said when natural gas came in, "Oh, it's just an old flame tarted up". Well, black underwear simply did not exist at that point and, if you wore a white petticoat when you went out in the morning, by the time you came back at night, it was filthy and you could not get it clean. For anybody who had to use white lace curtains (which I must say I hate, but I lived in a ground floor flat at one stage) the problem of actually getting them clean in the 50s and 60s was immense. These are things which are in my memory but anyone a decade or so younger than me I guess would not remember them and, if I may hazard a difficult comment, looking at the average age of delegates to this conference, it is very important to broaden the age range of representatives here and broaden the sex balance of the representation, if we are going to go forward to look at some of the problems likely to confront us in the future.

Now to something completely different. I would like to spend a few minutes on the work we tried to do on the Commission on Energy and the Environment; the result of our work is not very accessible because the report costs £23 but it was very, very hard work and I think of it as "Never mind the quality; feel the width". I have not even been given a personal copy of the report yet; I had to beg one from the Department of Energy on Wednesday at the Press Conference because I said I was coming down to this Conference and, if I came down here without a copy to show you, you would not believe that we had really done the work.

As you will know, we published the report on 30th September. It was the result of about 2½ years of very detailed work, covering a wide range of issues on coal production, supply, use, conversion to other fuels, and the associated environmental and planning issues. Evidence was contributed by a large number of people - 74 organisations and individuals, including the local authority associations, and many individual councils. The Commission also undertook a number of visits around England, Wales and Scotland, which involved discussions with many more local authorities. I do not know, as this is the only Commission I have been on - whether that was very conscientious or not on both sides.

Before making a few points about the Commission's report, I would like to talk about our approach to the work. The Commission, as was encapsulated in its name, the Commission on Energy and the Environment, was to advise on the interaction between energy policy and the environment. Our approach is (as we say early on in the report) perhaps best characterised in a quotation from Lord Nathan in his (1974) report 'Energy and the Environment': "A policy for the development of energy resources must be created in the context of its environmental and social consequences. Protection of the environment cannot be separated from the other objects of a policy for energy. The present skirmishing between environmental interests and the energy interests benefits neither side". We took that as our starting point.

We also had a variety of other commitments. We were not meeting in public as the Energy Commission then was, but we have been very open in receiving evidence from everybody and we decided that all the evidence submitted to us should be made available to people through the office at the Public Records Office and libraries. I am personally going to give all my evidence to the Open University, where I used to work for 11 years, which has a substantial Energy Research Group. They are welcoming the receipt of that evidence to contribute to their library with some pleasure. We were and are very keen on encouraging more open debate, and I shall come back to that again, briefly.

The further we progressed in our study, the more we became convinced that energy policy could not be made in isolation and that every decision was likely to involve industrial, social and political objectives as well as environmental ones. And we therefore examined not only the environmental consequences, but also a range of energy and other issues. We did get into debates about how far to go, about what was really a social effect, about where we should draw the line. I think if we had taken the broadest definitions that some of us were arguing for at some stages, we might have still been sitting, the report would have weighed about double and it would probably have cost at least £50.

In the event, I must say that we were extremely grateful to Sir Derek Ezra and his colleagues for the input of information and the co-operation that we received at all stages. Indeed, that goes for the other industries - it was not just the Coal Board who were involved at times, although the study was on coal.

Turning to the Commission's perspective, we were looking at developments over the next 20 years. We had some amazing meetings - I do not know whether they have happened before or since - in which the Central Electricity Generating Board, British Gas, British Rail, the Coal Board, were all ranked up along one side of the meeting, all discussing common issues. They admitted at some stage that they never normally got together and discussed such matters. In that sense, we did believe that we were doing something quite important for the country, actually to have all the different parties looking at those issues together. I know that Sir Derek and I share a common view that it was a pity that the Energy Commission was abolished. It may not have been a perfect forum for discussing energy policy but it was a forum in which all parties to the energy debate came together. Energy is an area of immense importance to the country and at the moment we do not have such a forum.

So we started out, many of us, with the conventional image that coal was difficult and dangerous to mine, that it inevitably caused environmental stress, that it was dirty and inconvenient to burn, contributing to air pollution and ash as residues to be absorbed into the environment. In fact, by the end of it, our conclusions were not like that. We came out with conclusions which, in our chairman Lord Flowers' words, were 'hopeful'. That is a moderate word. I do not mean that negatively, but rather it is a modest word. But the conclusions were hopeful.

We did indeed find features of coal-mining and its use which posed serious problems, particularly opencast mining; we were very worried about carving up yet more acres of the little that is left in Yorkshire. One of the serious features of spoil disposal is the fact that one is now creating almost as much spoil as coal: for every tonne you mine, you are creating about a tonne of spoil. That fact actually petrifies some of us. As do some of the aspects of subsidence, for example, people being left for really several years with cracks in their houses. Admittedly, they knew they would get paid for it to be mended in the long run but they actually had to live with a grotty house, possibly for quite a long time, and that is not pleasant.

However, aside from opencast mining about which we made a range of recommendations, we did end up believing that the worst features of coal production and its use are basically an inheritance from times past. We were particularly reassured by the progress which is really reflected in the contrast between previous standards and the standards to which new projects - such as the Vale of Belvoir - are being planned and executed. Our overall conclusions are therefore definitely hopeful, both for the coal industry and for coal prospects generally.

This Society, of course, has a particular interest in what the Commission says about air pollution from coal combustion and, if I range more broadly, you will understand why I am doing so but you will also understand that I know that your particular concern is for clean air. All of you are consumers and intelligent people and you will not take it amiss if I do not limit my words too narrowly.

Many of you in your local authority roles are interested in the problems that may or may not arise from the largest anticipated increase in coal burn in the industrial sector where, apart from the major industries which are looked after by the Alkali Inspectorate, local authorities of course have the main regulatory role. Many examinations of air pollution or any other effects of coal combusion, and the adequacy of controls, must of course take into account the fact that any major social activity is likely to have bad effects as well as good ones. Absolute safety is just as impossible to guarantee with the combustion of coal as it is with the generation of electricity, either by nuclear or by other means. There are costs and benefits in living in any industrial society and, while every effort must be made to limit the impacts and the incidents of impact on health, I for one do not think that many people in this room would want to go back to living in a pre-industrial society. I know some people do. There are odd people who say that they will go back and live without washing machines and, when I challenge them about how they are going to wash their sheets, they forget that the sheets have now got terylene in them, so they can actually wash them more easily than when they were heavy linen. The reality of going back to a pre-industrial society is not what people are really talking about. Therefore we are looking at the costs and benefits to us all of living in an industrial society and we are balancing against some of the costs, the benefits of the rising standard of living, the reduced infant mortality, better health, all the other things which, when we choose to remember it, we know are plusses.

The major adverse health effects of the pollution resulting from coal combustion, have arisen of course from a combination of smoke and sulphur dioxide, levels of which, particularly smoke, have been greatly reduced in the last 30 years. There is clear evidence of this, and this was reinforced by one member of the Commission, Sir Richard Doll.

It was a frightening Commission to be on, with such pundits. If, like me, you are appointed as 'the ordinary consumer', alonside Lord Flowers, Sir William Hawthorne and Sir Richard Doll, all of whom are names in the newspapers, you sit and listen to them as if they literally are the pundits. After a bit you realise that, just occasionally, what they need is a bit of ordinary common sense. Sometimes they are so locked into their particular speciality, that they have actually forgotten the ordinary common sense bit that most of us have to live our lives on.

However, one fact I did believe from Sir Richard Doll was that the reduction of smoke and sulphur dioxide has really resulted in the disappearance of acute effects on health, and that the incidence of long-term chronic effects has been substantially reduced. Nevertheless, we concluded that it was absolutely imperative not to be complacent and that we have to keep smoke pollution down to the lowest practicable level, come what may.

Sir Richard also said, at our Press Conference last week, something which I had not known - although it is implicit in the report - that the amount of lung cancer due to smoke produced in the absence of cigarette smoking is so low as to be virtually impossible to measure. If nobody smoked cigarettes, the damage from coal smoke would be much, much less, about 10 - 20 cases a year, rather than at the present level of 150 - 200 cases a year. So, if I may revert to my first theme, if we were all non-smokers, we would at a stroke have minimised one of our major problems quite a lot. The way in which smoke interacts with cigarette smoking is an important factor which I think is probably not very well understood.

Coming back to the role of local authorities, they are going to be particularly important in ensuring that the increase in coal use, desirable though it is from an energy point of view, does not put at risk all our post-war progress on environmental protection as embodied in the Clean Air Act, the Town and Country Planning Act and the Control of Pollution Act. We concluded in the Commission that there need not be a backward step in air quality but we felt we had to emphasise four things. Firstly that we were not entirely satisfied that local authorities were properly aware of the likelihood of the increase, particularly in industrial coal use, over the next 10 or 20 years. So local authorities have got to become aware of and plan for a possible quadrupling of use in industrial coal burn by the year 2000. We think that monitoring of levels of smoke, sulphur dioxide and other pollutants must continue. Individually one pollutant may not be dangerous but, where there is a build-up of a multi-source, it is absolutely necessary to keep a careful check on levels of air pollution.

Another area where we had a great range of discussions concerned the possibility of a reversion to coal-burning in homes. Some people are already going back to burning wood. Sir William Hawthorne is quite convinced that everybody will want to have open fireplaces and burn coal. He said at the Commission meeting, "My wife will clean the grate, she will continue to clean the grate!" Some of us coughed and looked at him and said that our wives were not going to carry on cleaning the grate. We are not at all clear whether people will want to go on cleaning the grate or, if in fact coal continues to be the cheapest option, whether it will be important for people to have the choice of cleaning the grate because in that way, they can keep warm more cheaply. But if coal is going to be burnt in people's houses, then it is absolutely imperative that the very good work going on at the Coal Board's Research Centre, Stoke Orchard, into smoke-eating appliances which burn ordinary coal in a smokeless way, continues. It is also important that as those new smoke-reducing appliances are brought on the market, their performance is carefully monitored and that they are used on an experimental basis before their use becomes widespread. Some of us do not believe that many such appliances will be used. Those who believe that they will be widely used hedge their bets by saying that they have got to be tested and monitored and used extremely carefully.

In principle, we believe there is a wide range of controls available to maintain air quality and that, provided these controls continue to be used and action is enforced on the sort of points I have listed, we think that there will not be any great problem. The point is not to get complacent about it. The problem is to find the right balance between the advantages and disadvantages and the costs and benefits. What looks as if it is a right balance to some people, looks quite different to others. One balance might look right if you are a local authority councillor; another might look right if you are part of the producing industries, and yet another balance might look right if you are a consumer trying to afford your coal, gas or electricity bill. The balance looks different according to whether you are a local resident with the pollution in your neighbourhood, or whether you are an energy user or an energy producer.

It is easy to measure some costs and very difficult to measure other costs. It is reasonably easy to measure the cost of putting an extra few feet on the height of the chimneys in Bedfordshire. It is much easier to put a value on light than to put a value on intelligence. I do not suppose any of us were comforted by the reports in the papers this week about the admittedly tentative work on children's level of intelligence when they have a high level of lead in their bodies. It certainly read to me like something about which I was not very happy, and I do not know how we put a value on those sorts of things.

The Commission has a fairly key chapter at the end called "Reconciling Interests", which was originally entitled "Reconciling Conflicts". I asked for the title to be changed to "Reconciling Different Interests" because different groups in the community do have different interests; that is inevitable and we need to discuss these differences and understand them. The particular problem, in relation to energy and to pollution, often comes in terms of balancing local interests against national interests and national needs. Everybody wants to be warm but nobody wants the coal mine; nobody wants the nuclear plant; nobody wants the SNG plant - even the CHP plant which is the favoured child of most of the environmental lobbies. Nobody wants any of these nextdoor to them. The same applies to hostels for alcoholics. The same thing used to apply to comprehensive schools. Everybody said they wanted them but they did not want them in their own neighbourhood and they did not want them for their children. And the same is true of most of the major energy developments that we are talking about. But everybody still wants to be warm and they want to be warm very cheaply.

How do we reconcile these different sorts of interests? I do not at the moment have any answers. All I want to say is that it is to the benefit of all of us to have much more open discussion about these different interests and try to work out what is in the genuine interest of the larger part of the community.

One of the difficulties, not so much in this country as in the USA, is that the development of single interest pressure groups, very often locally based, is very difficult to cope with when you are trying to reconcile these different interests. I do not think the Clean Air Society is one of these, although Lord Avon described it as such. What people in such groups usually have in common is that they are usually fighting against other things rather than for something and they coalesce simply to fight that problem at that time. They are not usually sharing a long long-term goal and a long-term interest. If they were, they would probably be in trade unions, or political parties, or in a consumer group. I am tempted to make an analogy to the SDP in the absence of that lot (the Labour Party Conference the week before) - where people are coalescing in one party, not so much because they are for something, but because they are against other things.

This is very often the case with single issue pressure groups. They can of course fight and win very valuable battles. However, if they succeed, it very often means that the self interest of a small group has overridden the interests of the silent majority. I think that is really quite dangerous.

The climate of opinion that we identify in this report is one in which we believe that people want open discussion, that people are no longer prepared to accept the judgement of experts, of politicians and of administrators. There was a general concern that decisions should be taken and be seen to be taken in the open, "reasonably, openly and fairly"; that local interests have to be reconciled with national interests. All of this requires, in our terms, more information and more education of people about the issues that are involved and about the choices that have been taken.

So if I may, in conclusion, come back to my two or three major points, one of which is that I really do believe that we must not be complacent. There is a major task to be done in remembering why we are where we are, and in looking to the future. This Society has a particular responsibility to keep people informed about the issues in this whole debate and about the choices involved in one person's pollution being another person's freedom. Governments, we believe, have the really vital role of stimulating debate about national energy issues into which then we would be able to place the framework of our discussions and our arguments. My second point is that we cannot have our cake and eat it. We have to make conscious decisions about what we do and live with them. Important choices have to be made. They affect our lives and the lives of our children. I personally believe - and if I may bring the discussion right back full circle to my new task which is a new national television channel, mandated to spend 15% of its air time on things educational, that this is a good thing since this country is actually profoundly under-educated. We really have to be better informed about these issues and be more active in the way that we take responsibility for our own decisions about them. For my part, if I can use my new role on Channel Four in helping to create a better informed debate and achieving better decisions about these issues in the country over the next year or so, then I look forward to making that contribution to your work.

SESSION TWO

ENVIRONMENTAL IMPACT ASSESSMENT

ENVIRONMENTAL IMPACT ASSESSMENT IN THE UK - ITS CURRENT STATUS IN THE LIGHT OF THE PROPOSED EEC DIRECTIVE

Dr. Brian D. Clark, PADC - Environmental Assessment
and Planning Unit, University of Aberdeen

ENVIRONMENTAL IMPACT ASSESSMENTS - THE PLANNING CASE

Donald L. Sabey, Director of Planning and Transportation,
Leicestershire County Council

MR. D. S. MACE (BP International Ltd.) opening the discussion, said that Environmental Impact Assessment was a very hot subject, judging by the number of conferences and seminars in which it was addressed. He applauded the decision by the NSCA Conference to limit themselves to half a day in Brighton when they could have had a week in the South of France or two days in Brussels.at the end of the week, or even two weeks in Aberdeen, at the end of the previous week. He also appreciated seeing Dr. Clark after the euphoria of Aberdeen winning; usually he met him on such occasions after Aberdeen had lost! In a sense he found it difficult to know where to begin in the light of Dr. Clark's definitive paper on the subject of Environmental Impact Assessment, and Mr. Sabey's very thorough review of a particular aspect of the subject. He was also in an ambivalent position in that BP had a requirement in its group health safety and environment policy that the environmental effects of any new development, project, acquisition or product would be assessed prior to commitment; therefore BP practised to a greater or lesser extent some form of environmental impact assessment and had done so for a number of years. Balanced against that, he was supposed to be representing private industry who, if the views of the CBI were anything to go by, were distinctly lukewarm on the topic of environmental impact assessment, particularly as set out in the draft directive.

He wanted just to make one or two general comments, then to talk in specific terms of how BP approached the problem, and then to raise one or two of the objections that industry had made, through the CBI or the Chemical

Industries Association or through the Petroleum Industries Association.

His first point was that he felt it was perhaps inappropriate that the discussion should be led off by industry, in the sense that the majority of the cases set out in Dr. Clark's and Mr. Sabey's papers were not ones that involved private industry directly. The majority of the cases cited involved either nationalised industry, statutory bodies or government sponsored projects. The Vale of Belvoir had been covered; there had also been the Windscale Inquiry, the inquiry into third London airport, and examinations of various water and trunk road schemes. The instances of private industry being mentioned were the North Sea rig construction sites which, in a sense, had been a very particular case. Equally, he thought that in looking at the impact on the environment of development, it was necessary to look at - as had been mentioned - the impact of averages and the impact of people in our daily lives. He had found it interesting, driving through parts of Surrey and Sussex that he had not driven through for 10 years, to see the healing impact on the countryside brought about by various local authorities, which had had a very significant environmental impact in those areas.

Referring to BP's requirement that the environmental effects of any development should be a set part of commitment, he said that it was equally a part of BP policy that the Chief Executive of each group organisation should be responsible for the environmental health of his or her particular area of the company. That concern and the expression of that policy had arisen out of experiences in Alaska in 1969/70 when the Transatlanta pipeline had been held up as a result of the National Environmental Policy Act requirement for environmental impact assessment. Thus, it had been decided at the highest levels in BP that they would never again be held hostage by failure on their part to consider properly the environmental impact of any particular development. They therefore had a system that required private commitment that projects be submitted to the department (of which he was the number two in the company), to ensure that proper consideration had been taken of environmental impact. In some cases they would undertake an assessment; in other cases they simply needed to be satisfied that it had been properly dealt with. They had a series of questions, not too dissimilar to the methodologies displayed on the screen by Dr. Clark, that they required to be answered or on which they required that evidence be submitted to show that they had been answered.

As a result, BP used environmental impact assessment as a management tool. It was able to answer management questions and the accountability that senior managers would have for the success of a project could be assisted, or the adverse accountability could be minimised, if it had been properly dealt with. They therefore treated environmental impact assessment as part of the decision-making process. They did not, however, regard it as a one-off type of exercise; one did not do an assessment and forget it.

BP regarded the whole environmental impact assessment procedure as a dynamic process. Assessment was undertaken prior to commitment. Assessment in detail was made during the design stage and subsequently the consequences of the assessment were built into the design. The construction was supervised to ensure that problems that had been foreseen were properly dealt with and that problems that had not been foreseen were equally properly dealt with. Then, subsequent to the commissioning of the particular plant, BP insisted and required that appropriate monitoring - both physical and ecological - should take place. They were at that time in the process of considering the first assessment they had done in the UK, for the Forties Field, to see whether the conclusions that had been drawn in that assessment were valid, whether in practice the impact that had been foreseen had occurred, whether subsequent modifications had been properly assessed and that the whole exercise was really worth doing at all. In such a way BP used EIA as an in-house decision-making tool, as a management aid, and therefore it was perhaps somewhat difficult for him to espouse the misgivings expressed in the evidence submitted to the House of Lords or to the House of Commons.

Turning to some of the points that industry had cited as problems in the draft directive, Mr. Mace said that industry tended to say that they approved of the principle of environmental impact assessment - but - and then there were a whole succession of 'buts'. They wished to avoid any question of additional delay, either bureaucratic or as a result of prolonged public objections and the possibility of litigation, the sort of litigation that had been seen in the United States. Equally they would like to see the draft directive capable of giving flexibility to national jurisdiction in the operation of the system, not to be absolutely tied to fixed procedures or fixed classifications of projects. Equally there was concern on confidentiality, for example in processes or alternative processes which at present could be handled adequately through the established channels of the statutory bodies, but might be a source of concern in the event of having to submit all the evidence through public inquiries. There was also concern on the probable inappropriateness of some of the classification within the annexes, and there was a desire that those be either limited or reclassified to cover only major impact. However, again with his BP hat on, he thought that that was the aspect that caused him some concern because there were certain comparatively minor projects - minor in terms of money or extent of impact - which nonetheless were extremely sensitive and needed to be handled properly.

Again, there was concern over the unnecessary involvement of the Commission; that, he suspected was either a left or right wing knee jerk to a view of the Common Market. There was concern that any requirement for environmental monitoring should be the responsibility of the statutory authorities and not local authorities, as seemed to be implicit in the draft directive, and equally there was concern that the discussion of alternatives to the project that the developer had in mind, should not be a prolonged, academic exercise. In many cases industry had no clear alternatives other than the one it was seeking to develop. Balanced against that there were cases in which there were alternatives, either of site or technology. Equally, he was concerned about Articles 6 and 7 of the draft directive, which he did not think reflected the realities of many industry investment decisions. Once an investment decision was taken in principle, by management, then the detailed design ensued, and quite often it was desirable to press ahead with the project before the detailed design was completed. Certainly that was the way BP worked. His department would do a quick overall environmental assessment, as to whether there were any fundamental objections to that decision from an environmental point of view. The detailed environmental assessment would have to follow later if there was not to be a very significant delay; he thought it was inappropriate to consider detailed environmental assessments in industrial projects if there was not to be a significant delay in the decision-making system.

Finally, he did not accept that, were the draft directive to be enacted and incorporated into national legislation, it would necessarily eliminate the way that planning controls were exercised. One had only to look at the considerable variety of ways in which EEC directives were enacted in the legislation of individual member states, and one could well foresee something comparable to the present disparities perpetuated with EIA. However, it had to be accepted that interest in environmental protection within the UK and within Europe was not diminishing, nor would it diminish. The potential environmental impacts of development could not be ignored and had to be taken seriously, either in such areas as visual, aesthetic impact or amenity impact, or with regard to land use planning or ecological values, even down to the ecotoxicological impacts. To ignore all those potential impacts, or any of them, to any serious degree, would be grossly irresponsible of industry. Equally, he did not think that it was a problem for industry alone; there were impacts from agriculture, impacts arising from local and national government action, and impacts that arose out of such areas as housing policies.

It would be wrong to think that environmental impact assessment was a panacea; that by doing an EIA, massive environmental impact would be avoided. One had only to look at the north slope of Alaska, the area of the first really significant EIA, which was now an enormous industrial area with very significant impacts, all of which had been very carefully assessed - and of which people were only now beginning to realise the full cumulative effect.

MR. MICHAEL GAMMON (Central Electricity Generating Board) said that part of his job was finding sites for power stations and then initiating the development of those sites, and carrying out negotiations with local authorities. He remarked that he was almost disappointed by how much he agreed with some of the previous speakers. However, he had some serious reservations about the introduction of the EEC directive. He asked the panel whether they would like to discuss how such a directive would ensure that the multitude of small and medium sized industrial developments, which in his view accumulatively did far more damage to the environment, would be improved. Further, how the directive could ensure that those people who were conscientious (and he thought that most of the larger developers were) would not suffer the risk of delay due to their opponents seeking to frustrate the project by arguing about what were reasonable alternatives, what were the other methods that could be used, what were the significant impacts, and why something they thought was of significant impact had not been studied in great detail, and that it would be a good idea to go away for two years and have a research project on it. Those were the sort of delays that he feared, and he said he would like to hear the panel's response.

MR. DONALD SABEY, replying briefly to the question of how the small and medium sized developments would be improved by the EEC directive said that the answer was that they would not be. The large developments were already taken care of as public pressure was brought to bear to make sure that they were dealt with adequately. He saw a danger in the list, because if a developer saw that his project was not on the list, he would say, 'I'm all right, I'm not on the list, I can get on'.

THE CHAIRMAN (Naomi McIntosh, President of the Society) said that she had been reminded of one of CENE's findings to which she had referred the previous day, that one major difficulty was the cumulative effect of multi-source pollution, of multi-source damage, which arose from the operation in one area of a variety of smaller industries or plants. It was much more difficult to assess the interaction of the different inputs and the way in which that multiple effect would build up.

DR. BRIAN D. CLARK replied first to the point about small developments. In that respect, he thought that one had to assume that the idea behind the directive was to try to identify those large-scale and contentious developments where, without any shadow of doubt, there would be controversy or problems from an environmental, social or health point of view. It seemed to him that the function of the directive was to say that, in the case of Annex 1, in virtually all cases, certain proposed developments had to be seriously assessed. One could indeed argue that in this country the majority of those developments were assessed anyway, and that that requirement would not entail any particularly additional onerous hardships. He thought that what was encouraging to some people, as had been picked up by David Mace, was that the directive might allow for more public accountability of certain public projects than existed at present. Increasingly there were clamours from certain people that public projects were not being given the same kind of evaluation and assessment as some private developments. He felt that small developments would continue to be picked up under existing legislation. Existing legislation, which said that under the planning acts, all developments had to be evaluated and that their effect on environmentally sensitive areas had to be taken into account. In that sense he thought that all the directive was trying to say was, "Let us try and codify the structure of something which operates in an *ad hoc* and pragmatic (perhaps flexible was a better term) manner at the present time". The directive also said that if a case could be made (and that was where he thought it was wrong to have to go to Brussels for an exemption on a case by case basis), exemptions could be made not only for

Annex 2 projects, but also for Annex 1 projects. It was up to the Government, under its own legislation, to pick up the small developments that had been mentioned. He felt that small developments, where there might be aggregated effects, could and would be covered by existing legislation.

Part of the second problem Mr. Mace had raised was the question of delay. Delay did exist at the present time in planning. One had only to look at the Dobry Committee report on this; the average time for approval of major projects in the UK was something like 27 months. His own experience, having gone through something like 40 major development application files, literally looking through all the documentation, was that there were incredible delays in the whole processing of applications. The delays were often due to people not being entirely clear as to what kind of information they wanted from the developer. The local authority were having to go back to the developer after the two months statutory period was completed, asking for more information. All that he was saying was that a more structured approach, which happened to have the loose name of environmental impact assessment, might have a role to play; in short, to see where some of the faults lay, the cause of delays, the costs, and whether in fact something could be done to speed up the process. There had been no evidence in the UK, presented either to the House of Lords or the House of Commons, of the actual costs and delays which occurred under the existing system and what the costs and delays might be under the new system. There was evidence from the United States and Canada that EIA accounted for approximately 1% of the total cost of projects. If that led to better developments with appropriate environmental evaluation being introduced at an early stage, it was a very small price to pay as part of the overall economic development.

MR. F. REYNOLDS (Director of Environmental Health, Leeds City Council) wished to make two or three points which could develop into questions as he talked. He said that most of the morning's papers and the discussion had related to the normal operation of large-scale industrial development. He wanted to refer to the possible abnormal operation of those industrial processes and the dangers which they posed; the Flixborough incident would obviously be remembered and those dangers could be related to any major hazard installation in the country.

The Health and Safety Executive, with the support of the Health and Safety Commission, and the support of the Minister, had recently refused to release details of the various highly dangerous major hazard installations throughout the country, although individual County and District local authorities would know of those in their own area.

He was not yet sure whether it was the intention of an environmental impact assessment to identify the potential arising from abnormal operation of those types of plant and, in such circumstances, how the public might be protected from the damage and hazards which would occur. He asked whether the members of the panel would care to comment.

Leading from the identification of a major hazard, the planning problems obviously had then to be considered. Having assessed by means of an EIA that a major hazard would exist, it was necessary to consider how that hazard should be minimised in respect of the local environment and population; for example, it might be necessary to consider a cordon sanitaire around the major hazard installation, thus effectively sterilising that land against future development. If such land was effectively sterilised, there was the question of who should pay compensation to the landowner. There was obviously a local/national conflict of interest.

It had been suggested at conferences and elsewhere that compensation should be payable by Government - either to the local planning authority which was served with a Purchase Notice, or direct to the landowner, since the proposed industrial development would clearly be of national importance and significance and it seemed unreasonable that the local ratepayers should suffer the financial burden of the sterilised land as well as the environmental consequences of the development. He asked for comments on that point from the panel of speakers.

Finally, he had been somewhat surprised when Mr. Sabey said, when discussing the Vale of Belvoir details, that certain matters would not have come to the fore had there not been an impact assessment. Mr. Reynolds had gained the impression that Mr. Sabey had been referring to noise and to dust. He felt that that must surely have been wrong. He was certain that many of those present had had the experience in negotiating with the National Coal Board in respect of both opencast and deep mine proposals when both noise and dust had been major issues to be considered. He had raised, at the 1980 NSCA conference, the bulldozer attitude of the NCB which seemed prepared to seek to avoid their environmental responsibilities if they possibly could. Because it was necessary to watch and monitor the NCB's every move, there was considerable expertise developing throughout the country in relation to the environmental effects of mining activities and it was recognised that any activity involving mineral extraction would cause considerable noise and dust, which were fundamental matters to be taken into account, whether or not a major EIA was undertaken.

DR. M. F. FOX (Leicester City Council and Lecturer in Environmental Control, Leicester City Polytechnic) said that, as a Councillor and a specialist in environmental control he thought he saw both sides of the issue. He remarked that it was possible to construct an EIA joke around the flight of the Israelites out of Egypt when the Red Sea parted; the point being of course that Moses had to write the environmental impact statement!

He felt that if something was discussed long enough and obsessively enough, it began to have a life of its own; that it was necessary to emphasise, from the elected members' point of view, that the environmental impact analysis, or statement, was an aid to the decision that members of council were there to take. If EIA was discussed enough, it would take on the form of a black box which turned up in council papers, which would have either a red light or a green light showing. It ought, however, to be a collection of assessments to which Members of Parliament, or of councils, or the Secretary of State, should apply their political judgement - which was what they were there for. That should be the order of things, and the environmental impact analysis ought not to make the decision for the decision takers.

Leicester City Polytechnic had undertaken, as part of the environmental studies degree, studies of the environmental investigation. Recently, attention had particularly been given to sensitivity analysis, i.e. how people assessed the various issues involved. First, it had been found that the site of the proposed development tended to be idealised. With reference to the Vale of Belvoir, for example, he pointed out that while it was a very pleasant place, there was an ironworks within the Vale, and one of Europe's largest petfood factories on the edge of the Vale, in Melton Mowbray, with possible water pollution and odour, etc. On the other hand, the advantages of employment tended to be downgraded. In Leicestershire one of the added edges to the Vale of Belvoir controversy was the fact that it was called the North East Leicestershire coalfield. There was already a North West Leicestershire field, which was running out of coal, where there was a substantial workforce with limited alternate employment. It was obviously very, very important to the miners, to the Coal Board and to Leicestershire to have a decision and to know under what conditions the Vale of Belvoir might be developed. But there was a general, very strong, presumption against development, in what was after all very much a man-made agricultural environment. He had been interested to note that people had been talking about applying environmental impact analysis to agricultural development, particularly to the way in which modern agriculture was going. He had said that there was a general strong presumption against development because Leicestershire had tended to be against employment-intensive development; it had been against the development of the Caterpillar Tractor plant at Desford, just outside Leicester, it had been against the expansion of the runway at the East Midlands airport and it had been against the development of the Vale of Belvoir. In conclusion, he thought it was interesting to note that since May 1981 the County Council had declared itself in favour of the Vale of Belvoir development, subject to suitable environmental safeguards.

THE CHAIRMAN said that she found herself looking ahead over 10 or 20 years, thinking that the additional on-cost of sending the spoil to the brick pits in Bedfordshire, which had been put at about £1 or £1.50 a tonne, would look cheap at the price in terms of removing one of the major damages to the Vale of Belvoir: all the appalling tips. As a personal comment, she felt it might be possible to have a bit more of ones cake and eat it, if one could pursue the Bedfordshire solution. She had found Dr. Fox's comments very interesting and very helpful, showing as they had exactly the costs and benefits, the choices and the judgement area. She had been lecturing at Middlesex Polytechnic at the stage at which CENE had been talking about those sorts of assessments being there to help reduce the area of uncertainty surrounding decisions and that had been precisely the point Dr. Fox made. EIAs should not be erected to the status of some fixed god, giving a spurious impression of accuracy, and taking away the ultimate power to make a decision.

DONALD SABEY, replying to comments made by Cllr. Dr. Fox, said that he hoped that he had emphasised in his paper that environmental impact assessment was an aid, was a tool, and was not an answer in itself. He would continue to make that point as he felt that one of the dangers of EIA was that some people looked to the assessment to provide the answer. Cllr. Fox had been quite right to draw attention to that. However, when he had gone on to talk about the Vale of Belvoir being "idealised" and had referred to the ironworks and petfood factory, Mr. Sabey had then realised how necessary environmental impact assessment was, if there was to be a balanced, structured approach to the environment. He said that it should be made clear that the ironworks was right on the edge of the Vale: and in fact was related to an existing urban area.

Further, the petfood factory was in Melton, and not in the Vale at all. Mr. Sabey thought, therefore, that Dr. Fox had been making the case for the organised, structured approach which would not allow wild statementw to be made, and would not allow of such generalisation.

On the question of employment, he agreed with part of what Dr. Fox had said. There were advantages in the opening up of the Belvoir coalfield, and indeed he himself had mentioned the fact that there would be in the region of 4000 more jobs. However, there was a counter-argument, that had also been brought out in the assessment, which was that in the North West Leicestershire coalfield, the existing part based on Coalville, there were something like 7000 men employed by the Coal Board, and by the end of the 1980s they would all be out of a job, because those mines were closing down. The Coal Board in their evidence at the Belvoir Inquiry had said quite clearly that Belvoir would provide 4000 jobs of which up to 2000 would be available to miners from North West Leicestershire, the remainder going to those from the South Nottinghamshire coalfield. Therefore, looking again at the North West Leicestershire problem, it could be seen that there would be 7000 miners out of work, with a maximum of 2000 jobs available provided on the other side of the county, which would obviously attract the younger element, and leaving a more intractable unemployment problem in the Coalville area. He was not saying that Belvoir itself was not an advantage in that it would provide jobs, but it was necessary to see the other side of the coin as well. Belvoir would not solve the problem of unemployment in the existing coalfield area, and indeed there was an argument that it could exacerbate it, because it would cream off the younger element, leaving a less attractive workforce for new employers coming to the Coalville area.

Finally, he wanted to put the record straight on two issues that had been raised. First, the factory extension (caterpillar tractor) had been approved by the Leicestershire County Council. Secondly, the Leicestershire County Council had not been against the development of the airfield in Leicestershire. What they had been against was tion could be given to planning conditions, mitigating measures and monitoring that could be incorporated. To sum up, an assessment of risk and hazard seemed to him to be an integral part of the process.

Dr. Clark did not want to take up the question of compensation in detail. The position in America, for example, was that environmental impact assessment was not mainly concerned with whether projects should go ahead or not. That was not the purpose of the legislation. It was whether environmental factors had been taken into account. Projects might go ahead even if an impact statement had said that every bird would be killed within 100 km. The project had gone through the legal process of evaluation imposed by the Act and it could then go ahead. What it had been able to do was influence decision-makers and act as a kind of pressure group for the environmental lobby. He thought that the presumption that environmental impact assessment was a mechanism for holding up development was something which had to be squashed. It was an attempt to try to get environmental factors taken into account at the right time. The President had posed the question as to whether the "no change" or "no go" situation was incorporated in an EIA system. In America and Canada and, for that matter, Thailand and the Philippines, it was an integral part of the impact assessment process and was fully incorporated as one option that had to be considered.

MR. D. BARRY (Environmental Consultant, Atkins Research and Development) said that one thing that seemed to be missing from the discussion was how EIA should be interactive rather than reactive. Should an engineering design be produced (and he used 'engineering' in a very broad sense) and then the effects examined, a lot of the potential benefits of the EIA process, in fact one of the main benefits, would be lost. How formal and how exhaustive the process was, could, he thought, be debated forever. What was major, what was significant? The proposals had to be looked at first in order to determine what was major, what was significant. At the outset, that was a problem; because for Mr. Mace, when a decision was made in principle to go ahead, it might be found, as with

Concorde, that implementing a design had greater implications than had first been considered. There was no way round that problem, particularly because of the lead time in major projects. However there was a vast number of projects where, by adopting an interactive approach at the early stages, problems could be ironed out before they appeared to the public or anybody else. Therefore, at the end of the day, a better design would be produced and the whole process of getting the development underway would be speeded up.

Turning to the point about confidentiality of process, he thought that it was a real problem. An instance that Atkins had been involved with some years before had concerned a developer who had been very anxious to 'come clean' on his development, and had asked Atkins to look at all the process emissions. Amongst those had been very minor quantities of arsenic. The public reaction had been "Oh, we didn't know there was going to be arsenic involved". Therefore, in a sense it was necessary to be very careful not just on the confidentiality from the industrialist's point of view, but in making sure that the data was presented in a form that did not actually cause alarm.

MR. MACE, commenting on the interactive question, said that he, within the BP context, would agree with it 100%. BP had recently been involved in a pipeline project, from an existing plant to one where there had been no pipeline before. Originally, the best alternative had seemed to be to take it through a very sensitive area involving one, if not two, SSSIs (Sites of Special Scientific Interest). Their first action, even when the pipeline had been just a gleam in the local general manager's eye, had been to talk to the RSPB, the Naturalists Trust and the local authorities. They had eventually arrived at an agreed route for the line, which limited the damage, long before any commitment had been made to go ahead with the project. Thus, they had cleared their most sensitive lines before they had even developed the project to the point where there was a cost estimate for anybody to take any action, and it had been an extremely useful interchange.

DONALD SABEY returned to a question that Mr. Reynolds had put to him specifically, as he wanted to put the record straight. Mr. Reynolds had said that surely Mr. Sabey knew that conditions could be imposed relating to noise and dust in the normal way. Mr. Sabey agreed that that was indeed so, and he had obviously not made the point very clear in his paper. The point he had been trying to make was that the Secretary of State on a number of occasions had told Planning Authorities that if a matter was dealt with by other legislation such as, for example, the Public Health Act or the Control of Pollution Act, then they ought not to make it the subject of a planning condition. Moreover, at the Belvoir Inquiry, the Coal Board had resisted very strongly any conditions relating to noise and dust on the grounds that there was other legislation to control them. Mr. Sabey thought that while that was all very well, unless such conditions could be brought in under the Planning legislation, they would not be subject to discussion in public and control by the liaison committees.

DR. BRIAN CLARK said that he did not want to respond to the question specifically but, having heard the advertisement for how BP and Leicestershire undertook EIA, he wanted to make just one point! He said that if people were interested in the whole subject of environmental assessment, and wanted to discuss some of the work that was being done on EIA and post audits, assessment methods, and environmental health impacts in the PADC Environmental Assessment and Planning Unit at Aberdeen University, he could let them have details. He and others at the unit were very interested in practical collaboration with local authorities and would welcome contact from them.

THE CHAIRMAN said that Dr. Clark's was a kind offer, and furthermore that the question Dr. Clark had raised at the beginning of his talk, of 'Quis custodet custodes' (who guards the guardians) was quite important. She felt that someone should keep an eye on what Dr. Clark and his colleagues were up to, and that he would welcome that!

SESSION THREE

LOW FREQUENCY NOISE

PRACTICAL ASPECTS OF THE LOW FREQUENCY NOISE PROBLEM

Hylton Dawson, Health and Safety Engineer, Rolls Royce (1971) Ltd., Aero Division

SUBJECTIVE EFFECTS OF LOW FREQUENCY NOISE

Stephen Benton, Chelsea College, University of London

MR. G. R. CHARNLEY (Assistant City Health Officer, Southampton City Council) said that when he had been asked to open the noise discussion he had been pleased that the low frequency end of the sound spectrum was to be the topic under review. It was an area in which relatively little information had been disseminated and which demanded considerable input into further research. At the 46th Annual Conference of the Society in Scarborough delegates had been told to investigate with their ears, and that the sound level meter and the A-weighting remained the panacea; that area of the sound spectrum placed far more emphasis on how the sound level meter was used, demanding at least a switch to linear or C-weighted measurements and extension of the frequency analysis in some instances down to below 1 Hz. Indeed the use of the A-weighting in design criteria might actually have encouraged the designer to opt for a lower frequency alternatives.

The Conference had heard two excellent speakers on the subject of low frequency noise; the dynamic Mr. Dawson, water diviner extrordinaire, (low frequency water-diviner perhaps was now more appropriate) had, as an alternative to "dilution being the solution to pollution" said it was possible to "throw jelly into a fan"! For those who had to deal with complaints from housing tenants, those living in high rise dwellings, the words "I'm sick of living here", might now take on greater meaning.

Both Mr. Benton and Mr. Dawson had provided delegates with some thought-provoking information. Mr. Charnley's only disappointment had been to read in the penultimate paragraph of Stephen Benton's paper that "In order to establish viable noise criteria it will be necessary to develop a cohesive overall model of hearing"; that could take years of research. He wondered whether it was possible to wait that long, in the meantime creating an international hum. Dr. John Snow had not waited until he was able to observe cholera vibrios under the microscope before chaining up the Broad Street pump to prevent its further use. Similarly the Chairman of the Environmental Health Committee and the local ward councillor preferred noise complaints to be resolved by yesterday as, of course, did the Ombudsman. In that respect, whilst appreciating the point of Mr. Benton's statement, he felt that the public would prefer to put the research findings in the cart behind Mr. Dawson's empirical horse. Mr. Benton's paper had provided a fascinating insight into human response to low frequency sounds. Turning a deaf ear might now have a new meaning and the possibility of learning from tape recording whilst asleep following appropriate cueing could in fact become a reality. However, when it came to pairing electric shocks with neutral words to elicit conditioned galvanic skin responses, he would far rather leave that to research volunteers in the laboratory!

One major problem looming up, judging by recent research discoveries, was that the man on the Clapham omnibus was becoming more of an individual and his auditory responses more difficult for the sound level meter, or even the EHO, to emulate; he wondered whether the law of nuisance would cater for that erstwhile Mr. Average in future or, perhaps even more difficult to answer, whether it should.

Mr. Dawson and his colleagues had embarked on a mammoth task of collating vast quantities of field data and had produced what could well become accepted as the authoritative work on low frequency design, at least until any research overtook it and especially as it had been written by an "industrialist". No doubt many local authorities would now test the water by setting low frequency planning consent conditions where such problems were likely to arise. In his own local authority, Southampton, they had been using what he had termed a flattened noise rating curve, i.e. flattened at the low frequency end, which would in future, in his own local authority at least, be known as "the Dawson criterion".

In his own experience reciprocating compressors at a plastics factory had caused severe nuisance at the house next door; dBA had not begun to quantify the problem but a pulsating sensation in the ears and forced vibrations of the windows in the lounge and bedroom and vibrating bath panels certainly had.

In passing, he referred to Mr. Dawson's comments about an apparent lack of communication between environmental specialists and planners employed by local authorities. In some cases, he had no doubt that that comment was fully justified and inexcusable. In others, the planning officers might well not have had their fingers burnt and chose to ignore advice given, and thirdly, pressure from the public needing housing might well have swayed the politicians on the Planning Committee who were always pointing out that it was they who took the decisions and not the officers - but whether they heeded the advice their technical officers had given them was another matter. Perhaps they would have done better to have done so. He thought that there was a lesson for all in Mr. Dawson's remark, not least for the industrialist who equally had no excuse for failing to develop and utilise his social conscience.

Although Mr. Dawson and Dr. Benton had given many examples of sources and effects, the problem did not stop there. Low frequency noise, to the man in the street, was the next door neighbour hi-fi enthusiast with the bass control screwed all the way up; it was debatable whether the building regulations could ever cater for that sort of problem. Another such example was the dance hall across the road where the bass drum was merely the means, via microphone and powerful amplification, to a high amplitude low frequency end. Professor Gavreaux and his low frequency gun had nothing on the big groups nowadays. One large group, ACDC, had even produced a record entitled "Rock 'n Roll ain't noise pollution": which was a worrying thought. Heavy lorries which made windows rattle, the quarry blasting along the road, and the 10 past 9 rumble from Concorde accelerating through Mach 1 many miles away across the channel were all low frequency to the man in the street; but those lonely individuals, the hummers afflicted with low frequency tinnitus, should not be forgotten. Many local authorities received complaints from such people and considerable time and effort was required in the investigation of that type of complaint. Sometimes there actually was a real noise from extraneous sources inaudible to the investigator but perhaps coinciding with a sensitivity peak in the complainant's hearing. Triggered tinnitus, where an external sound source could excite a different frequency in the ear, occasionally explained the noise heard. Even microwaves, well below the 'safe' doses from microwave ovens, could produce auditory sensations. One gentleman living in Reading had alleged that his buzzing noises were caused by radar beamed at him from Southampton! The majority of low frequency tinnitus problems, according to Mr. Walford of the Institute of Laringology and Otology, centred around 40 Hz. Many complainants described a throbbing sound like a pump and although the cause was still uncertain, low frequency tinnitus might be vascular in origin.

When he had first heard of the Bristol hum, he had wondered what might be the cause. Apiculture had been popularised but hardly, he thought, to such an extent, and in the middle of a city. If low frequency tinnitus had been the problem one might expect a more random distribution of hum complainants than with real noise causes, possibly with some focussing which might elicit, in fact, pockets of complainants. Possibly the Chairman and Mr. Dawson would be able to throw more light on that idea. One resident affected by the Bristol hum had written to the press saying "I have been having it on my radio chiefly on Sunday nights. It makes my radio hopeless, especially when 'Your Hundred Best Tunes' is on". At any rate, Mr. Charnley hoped that the Bristol hum would not be beamed on Southampton.

THE CHAIRMAN (Mr. L. E. Robson, Bristol City Council) thanked Mr. Charnley for his customary stimulating comments. He was sure that the authors would wish to take up a couple of the points he had raised. He wanted himself to comment on the "Bristol hum" and said that complaints had been widespread in Bristol: there had been well in excess of 100 complainants emanating from all over the city. There had also been complaints drawn to their attention, probably because of the press coverage given to the subject, from as far afield as Canada, USA, New Zealand, Jakarta, and many other areas. As to the geographical distribution of complainants with a genuine problem, as indicated in the figure that Hylton Dawson had presented, he suggested that people within a five to six kilometre range of the main industrial estate had been seriously affected.

MR. STEPHEN BENTON, replying to the point made about problems in deciding at what stage scientific data should be adopted, said that it was a traditional dilemma for research workers, ranging from whether data generated by scientific research should be applied, to when it could be applied. That type of fundamental problem was usually determined by tolerance to change and by the need for change. Noise research showed the familiar picture of a multifaceted problem being investigated by multi-disciplined research teams.

It was agreed that the widest possible frames of reference were required in order to understand the problem and therefore hopefully to get at the fundamental relations involved. In effect, what were needed were the best possible criteria upon which decisions about aspects of a source and its effects might be assessed.

Therefore, throughout the scientific community, researchers, each working in depth in their own specialist area, tried to construct criteria based upon their own and others results. Many views would be put forward and many forms of data analysis employed. Any subsequent interpretations would usually have undergone strong critical analysis which hopefully would yield valid results which, when considered together, would provide broad guidelines.

Whilst that was how scientific data might be processed and filtered, for pragmatic application, that did not mean that researchers were not aware that everyday problems needed immediate, or as near as possible immediate, solutions. Those solutions might not represent the finest stage of research, but they might provide relief for individual sufferers.

The result was a compromise, which took the form of general safety margins, for example curves such as N.R. ratings or intensity levels based upon dB(A). The point, however, was that such guidelines were not intended to be impervious to advances, advances brought about either by research or by experiences based on practical problems. As those guidelines became more and more sophisticated so must any suggested improvements. Knowing for example that dB(A) had limited use at low frequencies was one thing. Both convincing and justifying new criteria was another. Acknowledging the limitations of dB(A) had served only to stimulate more questions about effects; therefore criteria needed to be better founded and reformulated. That process logically entailed developing comprehensive terms of reference which in that case required developing greater understanding of the hearing system. That in no way prevented short term benefits from being established.

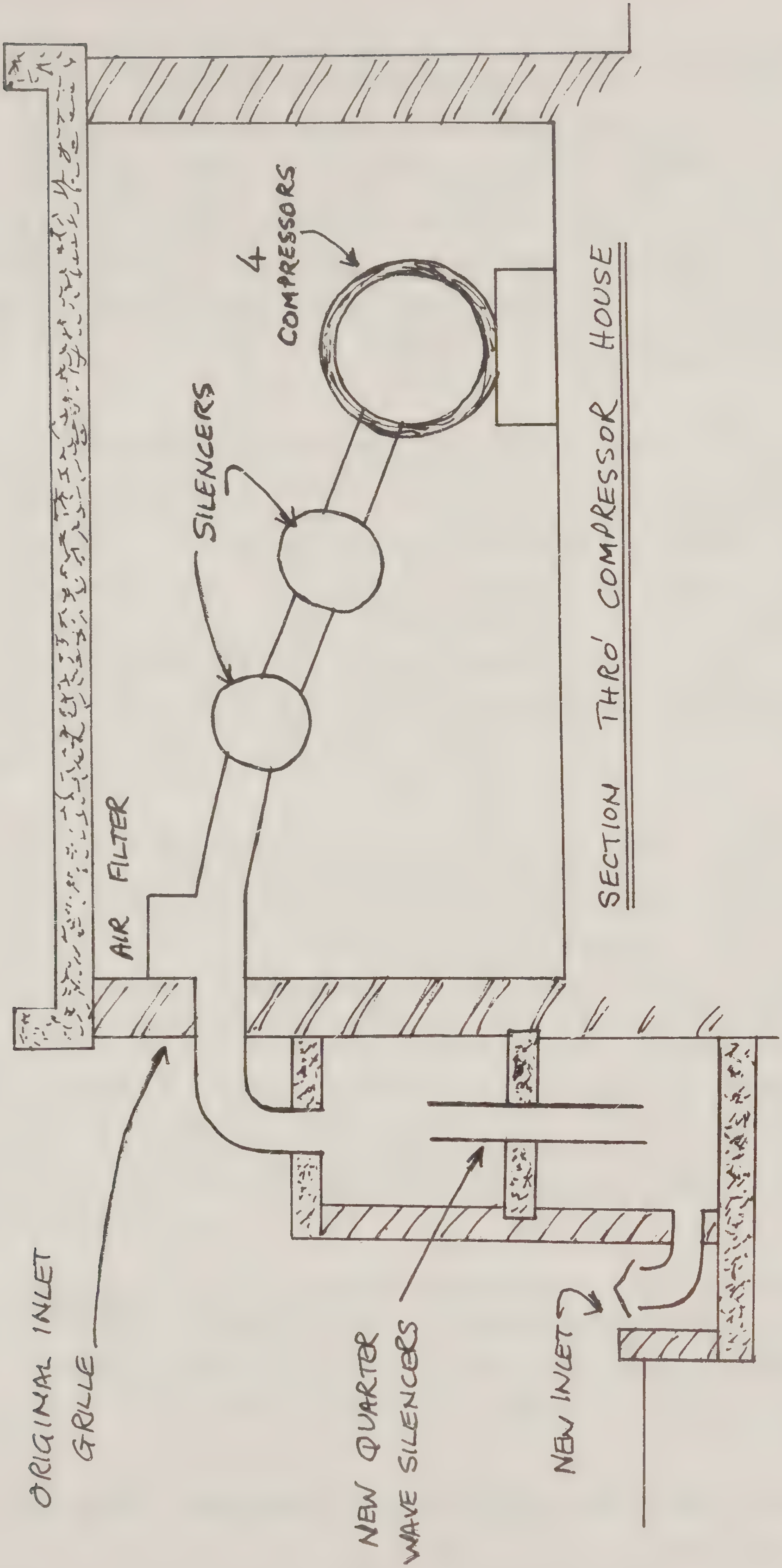
MR. HYLTON DAWSON, replying, thanked Mr. Charnley for his kind remarks. On the question of criteria, he hoped that it had been made clear that the dBA criteria had immense limitations; they were really not relevant to low frequency noise problems and regrettably, even amongst industrialists at present, too many people were playing the numbers game, "it meets the dBA criteria". Therefore, there was a vast educational job to be done. He was absolutely delighted that Mr. Charnley and his colleagues were going to take up the rather empirical criteria that had been derived. He thought that the water did need to be tested, and that in that respect the National Society for Clean Air had a very important role to play in bringing together the people with the problems and in keeping that particular debate alive.

Secondly, he felt that Mr. Charnley's remarks about the industrialist should be taken to heart; clearly not enough industrialists were either aware of the low frequency problem or were designing out low frequency when designing plant and machinery. In many cases it was really quite easy and fairly cheap to design out that problem but to then try and remedy it once plant and machinery had been built and installed was a fiercesomely difficult job. Tied up with that were the well chosen remarks about the Building Regulations, as it should be remembered that the laws of physics were involved. Mr. Dawson displayed a viewgraph that showed the attenuation on the left hand scale in decibels of any structure, whether it was a sheet of paper or a brick wall or a lump of concrete, against a parameter on the bottom scale which was the sound frequency, times the surface weight (i.e. the weight in pounds per square foot) of whatever material was in question: if it were chipboard it would be about one pound per square foot; that curve contained both some good and some bad news. The good news was that for a given weight of structure, every time sound frequency was doubled the attenuation of that structure increased by 5 dB. It was therefore ridiculously easy to attenuate high frequency. The bad news on that curve, however, was that every time the weight of a structure was doubled, attenuation would only be increased by another 5 dB. The slope of the curve showed that the attenuations were absolutely minimal at the lowest frequencies, so that there was an inherent problem, based on the laws of physics. It was therefore no good saying, if there was a low frequency noise problem even from the hi-fi next door, that the wall mass should simply be increased. That way, a fortune would be spent for no really beneficial result. It could therefore well be that the Building Regulations did need to be re-examined, and he thought that the sooner a debate was initiated and continued on a fairly high technical level, the better off one would be in terms of the rumble that had been discussed.

MR. BRIAN DOUGLAS (NSCA North West Division) said that as number of speakers had mentioned compressor problems, he thought it appropriate to refer to a case history which dated back to the 1960s with which his section had been involved. It concerned a compressor house containing four large compressors, 4000 cfm each. The compressor had a pair of pistons with a very large surface area, about 2 feet diameter, and a very short stroke. The compressor house had been pumping about 16,000 cubic feet a minute with one of the compressors varying the loads - 15, 14, 13, 12 or whatever. The problem had been that, as was not uncommon, the compressor houses had been situated on the boundary of the site pointing out towards the housing estate 250 yards away. There had been a lot of other associated fan noises in the area but the compressor noise had not been detectable other than as vibration on the structure, best detected with the finger tips on the window panes. It had also caused problems with loose doors, ornaments on the mantelpiece and in the bathroom.

Again, that case had demonstrated that using only dBA was completely irrelevant and also that the ear itself was unreliable. On those compressors, the air inlets had been connected to a horizontal silencer and each pair of silencers then connected to a third silencer and to an inlet on the side of the building, which itself had been a massive concrete and brick structure. The problem had raised discussions with Councillors, resident groups, the firm concerned and the environmental health department and finally acoustic consultants had been employed. Very close co-operation between the EHOs and the consultant had been arranged, with readings and cross confirmation being made over a period of 6-8 weeks. A bolt-on silencer on the roof had been tried on a sale or return basis but that had proved completely inadequate. Finally, after weeks of discussions and co-operation, they had ended up with a series of large brick boxes, which were quarter-wave silencers.

That was the first time he had come across that apparently magic answer to a lot of problems. When the analysis had been carried out it had been found that the frequency was a low frequency sound, down well below 30 Hz, and by carrying out the necessary calculations, a box about 18


4 COMPRESSORS
SILENCERS
AIR FILTER
SECTION THRO' COMPRESSOR HOUSE
ORIGINAL INLET GRILLE
4 NEW QUARTER WAVE SILENCERS
NEW INLET

feet tall had been designed, containing two compartments with a floor across the centre giving two 9 foot cubes with a pipe between the two chambers also of a set length with slotted ends. The inlet at the bottom had stuck out from the side with a little Chinese cap on. It was now possible to stand alongside those four silencer inlets and not know whether the compressors were running or not. He assumed that it had taken the bricklayers 2-3 weeks to build them and they had probably cost less than the advice given by the acoustic consultant in the first place.

One interesting aspect was that the noise from the compressor house had crossed a railway line in a brick lined cutting and then a park, to reach terraced houses 250 yards away. The block worst affected had been the front one but there had also been a couple of complaints from the street behind. The low frequency noise had obviously been reflected off two large gabled walls round on to the street at the rear and then back across the road again, which illustrated that the noise often went to places which were, at first, unexpected.

Two other compressor houses had since been built to the same design without any further problems. He thought that many of those present would have been able to tell similar stories over a wide variety of experiments. He also had come up against people with PhDs from research departments who had carried out checks and not gone below 63 Hz on their analysis and then advised their clients that there was no problem. He generally supported Mr. Dawson's contention that there ought to be some form of collaboration on such experiences, together with a bit more publicity and advice, put through the profession, about that very serious problem.

MR. CHARNLEY said that in Southampton the University had resolved one problem using a tunable reactive silencer method which could be slid in and out like a trombone and tuned in to the actual quarter wave for the silencing effect.

Taking up Mr. Douglas's aside that the remedy was cheaper than the advice of the consultant offered, lead him to the point of the EHO actually setting himself up as a consultant. He had grave reservations as to whether an EHO should attempt to do that; he thought it was fair enough if there were fairly straightforward, well tried solutions, or perhaps if there were well qualified EHOs or technical staff in the department. However, it should be remembered that if the consultant got it wrong, he paid; he wondered if the EHO would have the financial backing if he got it wrong.

MR. DAWSON thanked Mr. Douglas for his interesting remarks. He felt that it was certainly necessary to remind those in the profession that the quarter wavelength in acoustics was a magic number; it was always a factor to be considered. Regrettably, in the case of low frequency, quarter wavelengths could be very big but Mr. Douglas's success with that particular installation was very pleasing. The question of propagation of low frequency noise also needed to be well understood. It did rumble on and on and on, and got around a lot of barriers. Obviously there was a fair amount of reflection occurring at the same time, but there was still enough of most waves to go over and around barriers. As Mr. Robson had said earlier, there were quite frequently complaints of noise from areas totally dissociated from the true source of the noise simply because of distance or topography. The price of freedom was eternal vigilance and in dealing with such complaints, it was really necessary to examine even the most unlikely alternatives before they were actually discarded otherwise it might be a case of the baby being thrown out with the bath water.

THE CHAIRMAN drew attention to Mr. Dawson's paper, which had laid emphasis on different climatic effects on sound propagation, particularly of low frequency noise. He advised caution when taking noise readings under temperature inversions.

MR. C. HOWELL (National Society for Clean Air, South West Division) remarked that it was said that some men had achieved greatness in a night - but rarely without long and careful preparation. While it was not for him to suggest what greatness the two speakers had achieved, there could be no doubt that the papers they had presented had been the result of long and careful preparation and he had been fascinated by the work of both experts. He did not know how many of those present were familiar with the definition of the word "expert" but his dictionary had told him: "ex - has been, and spurt - a drip under pressure"!

On a more serious note, he accepted Mr. Dawson's contention that the dB(A) scale was totally irrelevant to low frequency complaints. However, assuming local authorities had the appropriate noise equipment to measure very low frequencies, he was wondering how to prove a statutory nuisance, having regard to criteria in BS 4142, ambient levels and dB(A). Until such time as the International Standards Organisation defined new curves and the new measurement unit and new meters had been designed and introduced, he wondered whether Mr. Dawson had any suggestions as to how Environmental Health Officers might tackle the problem in a positive way at present, if those causing the low frequency problems would not willingly co-operate, say in accordance with Mr. Dawson's empirical criteria in figure 18 of his paper.

Mr. Howell's other point was that the wind throb from partly open car windows had always conflicted in his mind with the "open-up and let's have some fresh air" feeling often suggested by his passengers. However, he had never found the time or the initiative to pursue the matter as Mr. Dawson had done. He had mentioned the sinister significance of that effect; but Mr. Howell asked whether he really thought that wearing ear inserts whilst driving was a wise or safe solution. Warnings had been given on the possible dangers of the new fashion of wearing headphones to listen to in-car stereo radio and cassettes. On the other hand he wondered whether Mr. Dawson thought that there might be a valid argument in that listening (at a reasonable level) to ones taste in music might have a beneficial psychological or subjective effect on the freshness of the driver after a long journey. There had been, that day, an example of music being interposed on an existing noise.

MR. DAWSON, referring to the political matters that had been raised, commented that all he could say was "Help!" He really did not know how the statutory nuisance could be proved. Were he to be facing such problems, and if it were possible to get hold of or borrow the type of equipment which had the frequency range under discussion, he would first of all try and measure any particular spectrum down to the lowest possible frequency. Were it also possible to obtain a tape recorder which was frequency modulated, it would be fairly easy to measure down to DC. Tape speeds could then be transposed and replayed back in the office at higher frequency, so that analysis would not be too difficult. The problem then was what to do with the result. Perhaps all that was possible was to quote whatever results had been obtained, maybe taking cognisance of the latest research reports to show at least some sort of comparison; beyond that he felt that he would certainly need political guidance from some of his EHO colleagues.

The question of wind throb on the motorway was one that concerned him and he and his colleagues had written to the Government, asking them to withdraw a government sponsored TV advertisement which asked people to open the windows if they got tired. The condition of photoepilepsy was known and understood and there had been a number of suggestions that acoustic epilepsy might be quite a real effect. All he could say on that point, bearing in mind that he had no medical qualifications, was that he certainly would not open his window on the motorway because of the wind throb effect, which he found unpleasant although fortunately he had never suffered from the low frequency sickness syndrome. He had, however, seen sufficiently dramatic effects on others who had, to make him really worry about it.

On the question of wearing earplugs when driving, he had never yet been in a situation on the motorway where he had either needed or necessarily got a meaningful acoustic stimulus. He tended not to hear the hooters of other cars if they ever used them. Most signalling was by flashing lights and indicators and he found that even wearing fairly good quality earplugs such as the resilient plastic EAR types, he could hear well enough. He could still hear the radio and the family talking or telling him to be careful, backseat driving or whatever. He did not therefore believe that earplugs posed any degree of hazard, and in terms of freshness after a three-hour drive, he found them very good. The car radio gave a useful masking effect. There were a number of people who questioned the use of car radios and, although he was quite happy to use it (it was a constant companion), he found that if he was in a stressful situation or approaching, say, a busy road junction, he always had to turn the radio down completely. There was no way that he could drive with an added stress factor, and that fact could well be related to some of the work that Mr. Benton had been describing.

MR. BENTON said that the problem lay in the need to fill out the bare bones of those guidelines which had been tendered by research. As had been said, it was all well and good having produced dB(A), but then what was called for seemed to be a development of annoyance ratings which provided information to workers in the area, over and above that of an intensity based reading. But as had been outlined, the problems involved there were immense. One of the problems lay in dealing with people that came from different disciplines ranging from physiology and physics, to psychology and biology. Having different backgrounds clearly would mean some problems occurring with respect to exchange of data and therefore it was bound to take time to establish understandable dialogue, with practical suggestions.

As for the stress category system, he thou ht that that was one idea that would probably be developed in the next few years, and rapidly so, because that approach was clearly responsive to the advances being made in physiological monitoring. People in the field seemed to think that with advanced monitoring it should be possible to construct reasonable stress criteria.

G. R. MILLINGTON (Wakefield M.D.) said that he had greatly enjoyed reading and hearing Mr. Dawson's paper. It had supported him in his contention that it was not sufficient to try and control planning and noise implications simply by specifying boundary noise levels. Whenever possible consideration should preferably be given to machinery and structures.

He also considered there was a great need for a more consistent approach by local authorities to the whole question of "planning and noise". He asked whether the speakers believed that local authorities in general showed enough interest, and developed sufficient expertise, in noise matters, and whether they felt that there would be use in some system for the collection of case histories - say via the National Society - with the purpose of establishing a form of data-bank of experiences.

MR. CHARNLEY entirely agreed with Mr. Millington about Mr. Sabey's comments that morning as to what the Secretary of State had said; planning legislation ought not to be used to control pollution which ought to be controlled by other more appropriate legislation. Mr. Charnley felt that development control was all about prevention, and the Control of Pollution Act and the Public Health Act essentially only sought cures which he regarded largely as a failsafe for the planner. Not only did the Control of Pollution Act and Public Health Act seek cures but in fact they only sought to cure nuisance. Nuisance had a special meaning in law which was a substantial interference. It was his contention that if the mere avoidance of nuisance was a satisfactory planning objective, then he would respectfully suggest that the planner should pack his bags and hand over to the EHO who for years had been clearing up the mess that the planner had left behind him. In his opinion the planner should aim whenever possible to prevent the deleterious addition of any form of pollution to the environment. He realised that such an objective would inevitably be tempered by realities but at least a standard much higher than the mere absence of nuisance should be achievable. He respectfully suggested, therefore, that Secretaries of State were not always right and that local authorities should continue to set reasonable planning consent conditions to prevent unnecessary pollution.

Turning briefly to Mr. Millington's second point, on whether local authorities developed sufficient expertise in noise matters, he thought that it depended on what problems local authorities had to deal with. The city local authorities inevitably had a plethora of the same type of problem and therefore tended to specialise; the rural authorities had many more acres to cover and did not tend to have the same degree of specialisation. He thought that in the odd case where the rural authorities were likely to have significant noise problems (gas pumping stations etc.) they should engage an acoustic specialist where necessary and should not force their own EHO into becoming overnight the "expert" to report to the Planning Committee.

Turning to the collection of data, he thought it was an excellent suggestion. The more case histories the better, whether they were sent to the National Society for Clean Air, or whoever, as an essential co-ordinator. The more examples there were, especially on the low frequency side, then the more it would be possible to learn.

MR. DAWSON believed that different approaches to the problem by local authorities were wasteful and inefficient in that although it afforded to those concerned in many cases the joy of rediscovery, that tended to be a fairly expensive pleasure. Therefore a great deal more standardisation was needed across the land. In terms of a co-ordinating role, he believed the National Society for Clean Air itself had a very important role to play and that it was tied up with the question of whether industry talked to the local authority enough. In the Bristol area, industry and local authorities had a healthy dialogue, under the aegis of the NSCA, and it had been of immense profit to both. If it was not happening on someone else's patch, he commended the practice. In addition, EHOs of course had their own professional bodies and perhaps those bodies could establish some sort of library of case law, with or without the help of the NSCA. The more such co-operation, the better.

MR. BENTON, commenting briefly on the point about pooling of resources, thought that it was an excellent idea and one which would be likely to enhance research work. For in accommodating practical examples, useful insight might be gained about the type of solution that would not only represent the best use of data but would reflect cognisance of both cost and implementation problems.

Secondly, throughout the country there could be found a range of problems relating to noise, and people faced with solving those problems often came up with useful descriptions and solutions. If those observations could be pooled, the extent, occurrence and types of environmental and personal problems caused by low frequencies could be documented. That would be similar to providing a data bank service, but one which contained observations and solutions suggested by fellow workers faced with similar financial and health considerations.

MR. C. N. PENN (Coventry City Council) said that one point he wanted to make in particular, was that the response to noise was very much subjective, and suggestion had been made that there was a need to try and establish some sort of criteria, against which the likely response to very low frequency noise could be assessed, always assuming of course that it could actually be measured.

He wanted to inject a note of caution in that context. In his experience, people who complained had no knowledge or experience of British Standards, Code of Practice or guidelines and it was essential to be very, very careful of setting any sort of guidelines, in whatever form they might be, and then to rely solely on that guideline as the absolute criteria, by which to be guided in determining human response. So if indeed the NSCA or indeed any other organisation were to provide an input to any further thinking on low frequency noise, he wanted to inject that note of caution.

He wondered whether he could also raise another issue which undoubtedly would arise while that was being considered, the question of the equivalent continuous noise level. It was being suggested, and had long been suggested by some eminent consultants, that that was the way in which human response ought to be assessed. Most people he had met did not even know what the continuous equivalent noise level was, let alone know whether or not they were responding to it adversely or otherwise. The Society might consider making some representations in that sense as well.

Finally, he had a question which had interested him since hearing Mr. Benton's presentation. He might have missed what he said, but a slide had been shown which related to measurements of low frequency noise, which apparently could be heard or felt by the recipient. However, Mr. Benton had not actually said what the source of the noise had been, whether indeed it had been a measured and recorded problem for which there appeared to be no determination of source and therefore no solution. He said that he would be grateful for Mr. Benton's comments.

STEPHEN BENTON wished to make it clear that the extent of their enquiries had been confined to the needs of that particular person. They had been concerned to investigate whether or not a sound, which constituted the noise, could be found. Having established the existence of a noise, they had presented the data to the Environmental Health Department. They had not been asked to locate the source; however, analysis of spectral data would permit reasonable guesses to be made. Source location had not been asked of them so that any interpretations about spectral characteristics were simply personal. That observation was made in order to minimise any likelihood of interfering with environmental health officers' work.

MR. DAWSON said that, in respect of Mr. Penn's question, he had consulted his colleague on the platform and had formed two deductions from the consultation. It had been suggested that in fact if one had a low frequency problem with some lady, all one needed to do was to increase the frequency! He commented that he was far too old himself.

Secondly, the concept of the 'reasonable woman' was used; he said that if anyone could tell him her telephone number he would be grateful.

THE CHAIRMAN said that it had been very clearly expressed by delegates that there was a limitation on the use of dB(A) when dealing with low frequency noise. He exhorted those practising, either as engineers or EHOs, not to forget the subjective test; old ladies should not be dismissed as frivolous complainants. He asked delegates to be aware of the problems of people tuning in to low frequency noise - it did occur, and it occurred regularly. He asked them not only to be conscious of the problems encountered by masking effects, but to remember that masking could also be an important feature when remedial acoustic treatment had been carried out; frequencies that it might have been thought were not being subjectively heard came to the fore once perhaps £30,000 had been spent on silencing equipment.

There had been a positive suggestion, made by Chelsea College, to pay particular attention to the 40 Hz range. That was important in that field of work. He warned EHOs that their comments on planning matters did have regard to the total background noise situation, not only in terms of L_{90} but also the frequency characteristics of their own district, and that might mean that local authority officers really had to do their homework thoroughly on the area of noise measurements, and that could include, as had been indicated, tape recordings. He had a further word of warning, on tape recordings, to be aware of the pitfalls involved: errors could creep in; such recordings had limitations. He made a plea from the Chair, that the academics would not run away and come out with another criterion of annoyance that would cost local authorities thousands of pounds in change of filters for sound level meters. Mr. Dawson's paper had, in Fig. 18, given a very useful Community noise criterion which, he assured delegates, in a few cases that he had dealt with in the City of Bristol, had worked in practice. He thought that the use of tape and chart recordings with the assistance of Community noise criteria such as Fig. 18 was of considerable benefit to practising EHOs.

Finally, he wished to draw delegates' attention to the need to implement the action plan that had been put forward by Mr. Dawson. He felt that to be a positive suggestion; and believed that it followed the remit that had been suggested the previous day by the Society's President, Naomi McIntosh.

SESSION FOUR

INDUSTRIAL POLLUTION - PRACTICAL SOLUTIONS

AIR POLLUTING ODOURS - CASE HISTORIES
Dr. Bernard Leadbeater, University of Bradford

INCINERATION OF TOXIC AND DANGEROUS WASTES - PRACTICAL ASPECTS OF DISPOSALS BY LOCAL AUTHORITIES AND INDUSTRY
Kenneth S. Dunn, Managing Director,
The Incinerator Co. Ltd.

THE RE-USE OF CONTAMINATED LAND
William D. Cowie, Assistant Chief Environment and
Control Engineer, West Yorkshire County Council

MR. A. E. R. BUDD (Johnson Matthey Chemicals Ltd.) opening the discussion, said that in his reference to his experiences with the Bass Brewing problem, Dr. Leadbeater had highlighted the discovery that the nickel and cobalt metal ions, which were present in that waste from the fertiliser manufacturing process, had a significant effect on the odour perception which was clearly shown by the chromatograph. He asked whether Dr. Leadbeater had any idea in what chemical way the nickel and cobalt were acting, whether it was catalytic reaction or a straight chemical reaction by neutralisation.

Secondly, Mr. Budd questioned Mr. Dunn on the economics of waste heat recovery and in particular, the difficulties that might be encountered with dirty or problem gas. Finally, turning to Mr. Cowie's paper, he asked about the possibility of methane recovery from landfill sites, and stressed the need for further research in order to reap the economic benefits.

DR. B. LEADBEATER replied that the short answer was "No". All too frequently people came along with these small problems as they had come along to Bass Charrington, and asked for a cure to be found; this was really the wrong way round. He had been approached by the Yorkshire Water Authority to do some work on the sludges, and was asked to find a practical method of stopping the smell; either by adjusting the pH or storing the sludge for a number of days or by some other method. That was generally the wrong way because the right way to tackle a problem was to find out the cause, how it arose. Often that could not be done with smells because of the analytical difficulties which had been illustrated. But the commonality of that kind of smell to the food industry suggested a throwback to some natural process, probably due to yeasts. Yeasts were largely composed of all sorts of chemicals in which there were traces of very complex molecules. It was possible to knock them back as with antiseptics etc. by more traces of other compounds, in this case, nickel; so it was some kind of poisoning or killing effect on to some form of organic life part of the smell-producing cycle.

MR. A. L. BEAMAN (Atkins Research & Development) expressed a deep interest in the field of odours, in which he had been working for some time. Dr. Leadbeater had posed the question of how much society should expect of industry, and what sort of levels of smell should be tolerated. Obviously he had given that question a lot of thought; perhaps he would be able to elaborate on the sort of criteria he had been adopting.

DR. LEADBEATER replied that there were many imponderables, such as the size of the industry, the number of people affected and the strength of the smell. The legislation needed to solve that particular question would be complex. The Americans had suggested that, for example, if there were more than 'X' occasions per month when an odour occurred, "something" ought to be done about it. That was really impractical because the smell occurrences were so very much affected by the frequency of certain weather conditions. Dr. Leadbeater said that he would welcome an answer to the question of what quantitative criteria should be applied - it would be quite a step forward.

MR. BEAMAN requested more details of the case histories generally, and asked Dr. Leadbeater what criteria he had chosen for Bass Charrington and the Brussels sprouts factory.

DR. LEADBEATER replied that in both cases - that of the tom-cat (amines) smell, that had arisen on Tees-side from the fish industry type of operation, and the Bass Charrington case - the good will or social conscience of the firm concerned had led to the cure. The graph of Bass Charrington's complaint reduction expenditure stretched over years and it was a case of sticking at it. The pig farmer would do nothing. Where he had 5000 pigs in a house ventilated at great rate according to the Ministry of Agriculture Food and Fisheries regulations on the quality of air at which pigs should be fed, he poked at a smell which could inundate a town and generally that fellow would do nothing about it. One pig farmer, who had that problem, cut down the emission of smell by cutting down on the ventilation of the air through his pig house to such an extent that by Ministry of Agriculture Food & Fisheries standards, the pigs should have suffocated. But it helped. He then fed them on a diet which made them produce very little solid effluent and flushed the liquid effluent down his drain. That meant passing it on to the Water Authority, of course! However, whilst that helped a little bit, the whole area stank - the question posed was what should the Society do? One of the consequences of doing anything about it would be an increase in the cost of pork sausages. It depended on the nastiness of the smell; the offal trade had been pretty remiss in not coming up with better solutions. Conversely the Warren Spring Laboratory's reports showed how very difficult it was to get the terribly high efficiencies which were required to remove the odd few molecules that the nose could detect.

The Brussels sprouts activity had shifted elsewhere. But nevertheless the case was worth thinking about a little bit because it was doubtful whether that firm should have been put to very much expense to have cured the problem. With reference to the question on the available methods of odour control, Warren Spring had issued some excellent reports on that topic. Catalysts and catalytic oxidation had their parts to play, but their effectiveness had been variable. In the case of a nice clean smell such as came from making potato crisps and dunking vinegar, they could be very good. But, in other cases, particularly those of the more traditional industries, like roasting coffee, treating offal and roasting barley, particularly where there were any traces of dust present, using catalysts could be very much like putting the maintenance of the Ferrari racing car in the hands of the ordinary garage mechanic. It was important to bear in mind that they had to be simple to use and there had to be adequate skilled supervision.

The excellent work by the Warren Spring Laboratory indicated that it was not easy to get to 100% smell removal. If the designer achieved 99% efficiency in the normal chemical engineering process, he gave himself a pat on the back but even the 1% of those very smelly substances whose nature was unknown, could cause quite a problem. So the smell expert took over where the chemical engineer left off. Each and every one of the treatment processes could be a step along the line, whatever was used - ozonolysis, absorption or adsorption. If they failed to go far enough, there was the other method of so-called control: that delightful theory of the tall stacks, whereby the stuff was poked up a chimney. That was very much an over-rated pastime. The average combustion installation, such as a power station working on sulphur-containing fuel, would send out an exhaust containing about 1000 parts per million of SO_2. The Memorandum on Chimney Heights aimed at a ground level concentration of about 16 parts per hundred million, in rough figures; so the real aim was to dilute what came out of the chimney by about 6000 times. If the stuff coming out of the chimney demanded dilution more than 6000 times before it got down to the non-smellable level, it was impossible to win. That was further compounded by the inadequacies of the atmospheric dispersion theory to explain fully the phenomena observed. The theory was not always right. The one little bit of naughtiness in the Warren Spring report was to take into account the fact that those calculations were based on a three-minute sampling time but it did not take the nose three minutes to detect a smell. Some sort of fudge factor had to take that into account. The report suggested that a factor of 10 was taken as being the required fudge factor, which might be about right, but then went on to talk about the rule of 10 times factor being acceptable - a supposition had become a rule. Thus a formula could be derived which was published for working out how high the chimney could be. Such a theory was unreliable.

KENNETH S. DUNN (Managing Director of the Incinerator Company Limited) said that, unquestionably, it was possible to run into difficulties with dirty gas or problem gas, in the process of waste heat recovery. That did not mean that work should not be done on waste heat recovery. The fluidised bed, for example, offered great hope of really good forms of waste heat recovery. The type of plant discussed that morning had a two pass economic boiler with a pretty high gas velocity - 30 metres per second was the actual velocity through the tubes - which stayed very clean under those conditions. So without question waste heat recovery was certainly something which should be further investigated. One of the troubles was that firms did not appear to want to pay the cost involved in sorting out and installing such systems.

There was also a lower size limit in terms of cost economy: about 450 lbs per hour in terms of throughput, which was a small plant, was about the lower economical limit for the type of general industrial plant under discussion. The work being undertaken involved investigating not only the small scale waste heat recovery, but the economics of other forms of fluid bed heat transfer. Much more interest was needed from industry; possibly, the encouragement of continued government grants for improvements in waste heat recovery schemes in boilerhouse projects would have resulted in more development to date. In any case, waste heat recovery was a must for the future. Incinerators generally were reckoned to be fairly useless things, although he personally did not subscribe to that view. If a boiler were added, it seemed an attractive proposition so why did not everyone consider a boiler? Even in the case of corrosive gases, the boiler could become an expendable item since with proper management of the waste and firing conditions, quite good payback periods could be obtained. If cars were expendable, why not boilers? Everyone seemed to want a boiler to last 25 years so there was certainly work being done and more would be done.

WILLIAM D. COWIE (Assistant Chief Environment and Control Engineer, West Yorkshire Metropolitan County Council) agreed that research was important but methane recovery was still in the experimental stage and the economics were unknown as yet. The plant could only be viable because the source of utilisation of gas lay immediately alongside the landfill site. Quite a lot of work was being done, by Harwell among others, on methods of getting the most of the methane from the decomposing refuse in the waste disposal site. But it was a new world involving new methods of tipping and much heavier plant. Some sites were producing in gas terms approximately 65% methane and 34% CO_2, so there were large quantities available for use. At present, the economics were unfavourable because of the cost of installation and the experimental nature of the work being done. However, such work had to be done.

CLLR. R. J. McELVENNEY (South Yorkshire County Council) said that Mr. Cowie had presented an interesting paper in which he set out some of the causes of land pollution. The only quarrel that he had with it was that Mr. Cowie did not offer any solutions to the reclamation problems that local authorities were facing. Solutions there were, as officers within the Environment Department of the South Yorkshire County Council had ably demonstrated. The reclamation of the toxic waste tip at Ravenfield was a classic example. But there was another solution to the problem of reclaiming contaminated and degraded land that would help authorities like West and South Yorkshire, who were experts in the subject of land reclamation – and that was money. It would appear however that the masters in Westminster had instructed the DOE that 100% grant to reclaim despoiled land could only be given for land that could be used for industrial purposes. In other words there was a shift in emphasis away from agriculture and recreational after use. That meant that the North (and

Wales and parts of Scotland were included in the analogy) was being condemned to remain the dustbin of the United Kingdom. It had been, and indeed still was, the power house of the country.

The North produced the bulk of the country's energy requirements and the raw steel and iron needed by the lighter industries of the the South, whilst the resultant debris remained on its doorstep. It was high time that the affluent fat cats of the South, living in their sylvan glades and their seaside ivory towers, became more realistic about reclamation grants. There was something cock-eyed about a situation where government ministers could decree that the South could have 100% grant to reclaim old sewage farms and dockyards, whilst the North could only receive a similar grant if its pit heaps, some of which would rival the Matterhorn or the Eiger, could be returned to industrial use. That was a totally unrealistic attitude. The North was fed up with its industrial wealth being moved south; it was the country's poor relation - the South lived off the North's industrial back whilst it was left with the debris. The people of the North were equally entitled to live in sylvan glades and ivory towers and they could do with a more realistic approach to reclamation grants by those who were blind in Westminster. Positive action was required and a concerted approach through the A.M.A. to the Minister of the Environment for a bigger allocation of grant to remove the eye sores of the North (not forgetting Wales and Scotland) into the Garden of Eden. Nothing would be achieved by politely arguing with the DOE about reclamation grants. They had to be actively fought for. Individual action was useless but collective action could achieve a great deal.

MR. COWIE replied that they had succeeded in getting 100% grants. Work on reclamation of a colliery spoil tip, which was going back to agriculture and forestry, had just been started. Perhaps relationships with DOE officers in the regional office were a little better than South Yorkshire's - maybe because of their proximity to the regional office, which was in West Yorkshire!

DR. A. W. C. KEDDIE (Warren Spring Laboratory) said that he had been going to comment spontaneously on Bernard Leadbeater's paper, and make a few general observations. However, Dr. Leadbeater's remarks had made it almost essential that Dr. Keddie should say something on behalf of WSL. He thought that Dr. Leadbeater's paper had provided a fascinating catalogue of case histories, and of the problems faced by industry and local authorities, when searching for environmentally acceptable and economic solutions. The greatest difficulties were of course frequently encountered when dealing with existing plant. Dr. Keddie wanted, with the aid of overheads (reproduced here as Tables 1-4. Ed.) to add some numbers to, as well as generalise on, some of the points that had been made by Dr. Leadbeater. He realised that not everyone liked quantification but said that it was essential nevertheless. His first overhead (Table 1) was an extract from a recently published WSL report. The second column gave the numbers of installations, or sources, which had given rise to odour complaints recorded by local authorities. Coverage of the United Kingdom was not complete, but it was fairly extensive and fairly representative. He wanted simply to illustrate that there was still a wide range of activities which still gave rise to odour problems.

The second overhead (Table 2) showed, in the second and fourth column respectively, some typical odour production rates and residual odour emission rates downstream of a very efficient abatement system. The third and fifth columns gave the corresponding expected maximum distances of complaint, calculated from an empirical WSL formula based on actual complaint statistics and assuming a near-ground source. Those were typical odour production rates for the specific industrial etc. processes, prior to abatement. Clearly, rather large maximum distances of complaint were to be expected, up to about 10 kilometres in some cases, if no abatement system was installed or if it operated inefficiently. If it was assumed that 98% abatement could be achieved, and that was also assuming that all the odour could be contained in the first place, the fifth or final column demonstrated that one could still expect to get reasonable maximum distances of com-

Table 1

12 MOST FREQUENTLY OCCURRING ODOUR SOURCES - RESPONSIBLE FOR 47% OF TOTAL NUMBER IN UK*

SOURCE TYPE	NUMBER OF SOURCES
MANURE SPREADING	58
SEWAGE TREATMENT	43
ANIMAL RENDERING	41
FOUNDRIES	40
PAINT SPRAYING	35
SEWAGE SLUDGE DISPOSAL	30
RESTAURANTS/KITCHENS	27
POULTRY HOUSES	26
PIG HOUSES	25
TANNING, FELL-MONGERING	19
ABATTOIRS	18
MAGGOT FARMS	17

* Based on WSL survey of some 240 Local Authorities

Table 2

SOME TYPICAL ODOUR "PRODUCTION" RATES

SOURCE	ODOUR "PRODUCTION"[1] ($m^3 s^{-1}$)	COMPLAINTS[2] (km)	98% ABATEMENT[3] ($m^3 s^{-1}$)	COMPLAINT[4] (km)
PRINTING	60,000	1.2	1,200	0.1
CRISPS	435,000	3.9	8,500	0.4
RENDERING	750,000	5.4	15,000	0.5
FISH MEAL	2,000,000	9.7	40,000	0.9
MAGGOTS	30,000	0.8	600	0.1
NYLON	36,000	0.9	720	0.1

(1) Calculated from gas flow rate (F) and dilution to detection threshold value (D), prior to abatement.

(2) Calculated from (1) using WSL formula for maximum distance of complaint, $d = (2.2\ DF)^{0.6}$

(3) Odour emission calculated from (1) assuming 98% efficiency.

(4) Calculated from (3), again using the formula for d.

Table 3

METHODS OF ODOUR ABATEMENT AND TYPICAL EFFICIENCIES FOUND IN PRACTICE

METHOD	EFFICIENCY
INCINERATION – THERMAL (800°C) CATALYTIC (400°C)	95 – 99%
ABSORPTION	80 – 90%
ADSORPTION	25 – 50%
BIOLOGICAL OXIDATION(1)	?(50 – 80%)
(MASKING AGENTS – USUALLY POOR AND UNRELIABLE)	

(1) Little experimental evidence available, especially for strong odours.

Table 4

STEPS IN ODOUR CONTROL IN ORDER OF PRIORITY

1. MINIMISE PRODUCTION OF ODOURS
   PROCESS CHANGES/CONTROLS; RAW MATERIALS
2. CONTAINMENT – MINIMISE VOLUME OF AIR CONTAMINATED
3. ABATEMENT – MINIMISE FINAL EMISSION
   SELECT CORRECT METHOD AND DESIGN
4. DISPERSION – DILUTE RESIDUAL EMISSION
   CHIMNEY HEIGHTS; LOCATION OF PREMISES

(1) and (3) require good monitoring and control.

(4) can be unreliable but necessary for any residual emission.

plaint, up to 1 kilometre in the fish meal case.

The third overhead (Table 3) to some extent summarised what Dr. Leadbeater had said about the actual performance of different abatement techniques. Those figures also assumed that it was possible to contain the odour in the first place and that the abatement equipment was being maintained and operated in a reasonably satisfactory manner, and had been designed for the particular job that it was being used for. The important point to note was that, in general, efficiencies were not as good as the 98% used in the previous overhead (Table 2).

Dr. Keddie said that incineration was very effective but expensive, particularly for high volume flow rates; it tended to be used for concentrated, low volume odour streams. Catalytic incineration, which had been referred to earlier that morning, could be equally efficient and universal in its destruction of odorous species but it had problems of fouling and poisoning in certain circumstances; the considerable advantage was of course on saving fuel costs. Absorption, which was perhaps the most common technique and the one that many local authorities would be familiar with, could very rarely achieve better than 90% efficiency. The method also usually had to be tailored to the specific odour being treated, i.e. the number of absorption stages, types and strengths of reagents, had to be optimised. Adsorption on activated carbon was in general very poor in WSL's experience, achieving only 25-50% in practice. Biological oxidation was a more recent technique which had not yet been fully evaluated. The 50-80% efficiency range quoted had to be regarded with caution, especially for strong odours. Masking agents, which Dr. Leadbeater had also referred to, were usually poor and unreliable.

Dr. Keddie said that his comments might have sounded rather gloomy but it was not his intention to leave that impression with the audience. Certainly there were difficulties and there was no magic solution but considerable progress had been made in the ability systematically to examine an odour problem, to select and specify the appropriate containment and abatement and to advise on the degree of dispersion required to cope with the residual emission.

The final overhead (Table 4) summarised the important steps in any odour control problem. Dr. Keddie said that the first step had to be to examine ways of minimising production of odour in the first place. That could mean looking at process changes or different controls on processes or changes in raw materials. Those changes did not always have to imply an on-cost for the industry concerned. Re-examination of the process could lead to process/product benefits as well as improved odour control. The next step was to contain the odour, i.e. minimise the volume of air which could become contaminated. Thirdly, abatement, which was essentially concerned with treatment of the contaminated air or process gases and therefore with minimising the final emission. The fourth step was to ensure adequate dispersion of the residual odour.
Dr. Keddie said that he had described the various steps in order of priority, and he entirely agreed with Dr. Leadbeater that dispersion was not the method to rely on for odour "control" or reduction of complaints. Nevertheless, there would always be a residual odour, potentially capable of giving rise to complaints (ref. Table 2).

Dr. Leadbeater had said that WSL were 'a bit naughty' because they had derived and recommended a chimney height formula based on dubious data and theory. Dr. Keddie said that he himself had been the author of the chapter in question, so that, if true, it was he who had been naughty! He said that he would be the first to admit that the chimney height formula for the dispersion of odours was not based on nearly as good data or sound theoretical considerations as WSL would have liked. It was not intended to be a strict rule but simply a first attempt at a guideline in the absence of a better one. The formula was broadly consistent with the odour emission/complaints statistics that were available to WSL and was also consistent with the fact that SO_2 could seldom be smelt from industrial combustion plant. Ultimately, decisions had to be made about required chimney heights, particularly for new process plant; the formula was a yardstick to facilitate that process. There might also be situations where it was sensible, or indeed economically necessary, to compromise on abatement and make greater use of dispersion by relying more on a chimney. However, the WSL manual on odour control did say quite specifically that steps 1, 2 and 3 (Table 4) ought to be followed first, and that step 4 was the last resort. In addition, Mr. Dunn had said that morning, and been endorsed by Dr. Leadbeater, that steps such as 1 and 3 required good monitoring and control. Dr. Keddie said that that did not of course refer to monitoring in the sense of ambient measurements, but rather monitoring the performance of processes and of the abatement equipment. Proper operation and proper maintenance were exceptionally important.

Finally, Dr. Keddie said that he thought the biggest problem at the present time lay in defining what was an acceptable odour in the ambient atmosphere, and that problem would exist for quite a considerable time to come. Nevertheless, it was an aspect of odours in which there was a growing interest, partly because more and more industrialists, the Water Authority included, were looking at how accepted guidelines on odour exposure could be incorporated into plant operational procedures, etc. What distinguished odours from everything else of course, and Dr. Leadbeater had referred to that, was that the odour emission rate could vary enormously over a relatively short or long period of time and its character or acceptability could also change substantially. That was much less likely in the case of conventional pollutants such as SO_2 or NOx. Specifications for an overall odour abatement system which would cope with all eventualities were therefore virtually impossible to define and when someone got it wrong the public would notice!

SESSION FIVE

LONG-RANGE TRANSPORT OF AIR POLLUTION

THE LONG-RANGE TRANSPORT OF AIR POLLUTION - A DECADE OF INVESTIGATION
Dr. R. A. Barnes, Esso Petroleum Co. Ltd.

CHEMICAL TRANSFORMATIONS IN THE ATMOSPHERE
Dr. A. S. Kallend, Central Electricity Research Laboratories

DR. J. G. IRWIN (Warren Spring Laboratory), opening the discussion, thanked Dr. Barnes and Dr. Kallend for presenting two most interesting papers. After listening to any description of acid rain, he was invariably reminded of the words of Oscar Wilde: "the truth is rarely pure and simple". One fact which emerged from both these lectures was the need for high quality long-term data to assist the study of long range transport and related ecological effects. He and Dr. Kallend were both members of a group which was currently reviewing the distribution of acidity in the United Kingdom and also the changes in acidity with time over Northern Europe to which Dr. Kallend had referred. Unfortunately there was a great shortage of reliable data.

Dr. Barnes had mentioned briefly the follow-up to the OECD exercise. That programme was started in late 1977 under the auspices of United Nations Economic Commission for Europe and known as the European Monitoring and Evaluation Programme (EMEP). Although similar in many ways to the OECD programme it was an improvement in two important respects. Firstly, as it was a United Nations exercise, many of the Eastern European countries were participating, so some information was available on transboundary fluxes between east and west. Secondly, the contribution of nitrogen-containing species to acidity was now more fully appreciated. All the participating countries were encouraged to measure nitrate and ammonium both in precipitation and aerosol at their monitoring stations. There were undoubtedly very great difficulties in doing so, due to problems of sample stability etc., but hopefully the exercise would provide more refined data than the earlier OECD one. In fact, the Western Meteorological Synthesising Centre of EMEP was currently carrying out some preliminary modelling studies using a fairly simple air chemistry scheme involving 60 reactions, 6 classes of hydrocarbons and very preliminary European NOx and hydrocarbon emission data.

One interesting point which had not been covered was the natural emission of sulphur containing species. When measuring sulphur-containing species, the study was of the total of both anthropogenic and naturally occurring emissions such as volcanoes and biogenic emissions from sea or land. Dr. Irwin invited the speakers to comment on the relative importance of those sources. Consideration of natural emissions might alter our concept of "unpolluted" air and make some of our conclusions liable to re-interpretation. He wondered whether enough was known about natural emissions.

DR. R. A. BARNES, replying, thought that enough was known for the area of interest. Natural emissions, both biogenic and volcanic, in Europe and in North America were inconsequential compared with man's emissions. However, in terms of the globe as a whole, they were very important. Biogenic emissions in particular tended to increase with ambient temperatures so that in the equatorial regions of the world, they were very significant. Volcanic emissions were obviously localised with the geography of volcanicity and temporarily with the occasions of violent volcanic activity but he thought that in the context of the long range transport of air pollution and its problems in North America and Europe, there was an adequate feel for those sources. There were many greater unknowns that it would be better to focus research effort into.

DR. A. S. KALLEND agreed substantially with Dr. Barnes; although he pointed out that probably the best estimates of natural emissions suggested that they could be about equal in global terms with man-made emissions. However, by far the greater part of anthropogenic emissions occurred in the northern hemisphere. Certainly in the southern hemisphere examination of, for example, ice-cores near the South Pole, would reveal evidence of every major volcano that had ever been known to have occurred, including Krakatoa, which was a long way from the South Pole. But a lot depended on what the base line was. Although natural emissions in the northern hemisphere might not be large compared with man's, it might well be the case that a very small amount of sulphur could have a disproportionate effect on the acidity of precipitation. Thus the natural acidity of rain might be of substantially lower pH than the often quoted 5.6, which derived simply from the amount of carbon dioxide in the atmosphere in equilibrium with water.

DR. IRWIN agreed that this was a most interesting point. Some picturesque slides of lakes in Sweden and Southern Norway had been shown. In a rather more parochial context: in Scotland, there were similar areas of low natural buffering capacity. He wondered whether any ecological effects had been observed there.

DR. BARNES thought that most of the interest had focussed around the work done by the Biology Department of CERL so he turned that question over to Dr. Kallend.

DR. KALLEND said that CERL had done some work, and were in fact still doing a limited amount of work looking at one particular catchment area in Galloway, Scotland. The specific purpose in doing that study was because CERL was investigating something that Dr. Barnes would have referred to if he had time: that there were other possible reasons why lakes and rivers could have become acidified, apart from the input of acid from precipitation. One of them was the effect that could arise from the changes in land use. In particular, if trees were planted, thereby foresting an area that had not previously been forested, that upset, or changed at least, the balance of chemistry that occurred in the soil. One of the things under investigation in Galloway was the effect of a newly forested area on stream and lake chemistry. Dr. Kallend drew attention to a report by Rosenquist in Norway who had come to the conclusion that there were many other sources of acidity in lakes and rivers that were much more important than acid rain.

DR. IRWIN recalled that Dr. Kallend had stressed the importance of ambient air quality regarding its influence on reaction rates within a plume. He asked whether both speakers felt that the current monitoring networks, for example EMEP, were adequate, or whether we should be simultaneously measuring hydrocarbons and other species such as compounds of chromium and manganese which act as catalysts in the atmosphere.

DR. BARNES said the simple answer was 'yes, very much so'; he thought that for too long pollutants had been looked at in isolation from each other. He saw the atmosphere over Europe and over the industrial parts of North America as being a huge chemical cauldron into which man discharged all his gaseous waste. Depending on the meteorology, particularly the temperature, the humidity and trace natural emissions (e.g. ammonia) a whole variety of different final compounds could be produced. He did not think it was possible to have a thorough and detailed overview until information on some of those other crucial pollutants had been obtained - and the ones Dr. Irwin had named he agreed with in particular.

DR. KALLEND agreed that there was a limit to what could be done with a limited amount of resources. Certainly in CERL's experimental flight programme, which had been formulated some four years previously, measurements for hydrocarbons, for example, had not been included. CERL's researchers now wished that such measurements had been included because in the intervening period they had begun to realise the extent to which different pollutants interacted. The level of hydrocarbons, among other things, could materially affect the fate of sulphur dioxide in the atmosphere. Another related point was that when reference was made to a plume from the power station at 700 km distance, most of the matter in that dispersed plume did not arise from the chimney at all; it came from the ambient air. It was substantially ambient air, in which there were traces of the substance from the point source of interest. Indeed, at that kind of distance, probably more of the nitrogen oxides in the definable plume had come from the ambient air and other sources, such as automobiles and so forth, than from the plume source itself.

COUNCILLOR J. C. BLEWITT, J.P. (South Oxfordshire District Council) said that his question was not actually on the agenda, but was on the related subject of the transport of black smoke caused by stubble burning. He felt that both in South Oxfordshire and in other rural areas it had become a major problem. The disadvantages to the general population now outweighed the advantages to the farming industry, which had been specifically excluded from clean air legislation regarding dark smoke emission. He asked whether the Society or any other body had recently carried out research, or collation of research, into smoke emission from stubble burning. If so, he asked whether a report or paper could be prepared for discussion and information.

Secondly, he hoped that the Society would support his plea that the problem had become so great that it was causing widespread anxiety; and that the Society should therefore take another look at stubble burning to see what, if anything, could be done to alleviate the problem, if possible without hurting the farming industry.

His third point was that, in addition to the Code of Practice on stubble burning drawn up by the NFU, South Oxfordshire DC had devised a bye-law. However, he felt that the Code of Practice was sometimes ignored and that the terms in which the bye-law had been framed were too loose to allow of effective enforcement. He thought that the time had come to re-examine both the Code of Practice and the bye-law. He asked the Conference to support his request that the Society should look into the matter, establish what could be done, and, if suitable legislative action were possible, that the Society should urge the Department of the Environment to progress it with all due haste. He felt that the time had come for the farming industry to be brought into line with other industries in relation to the emission of black smoke. He thought that the people affected found it a great problem and that it was a matter for urgent consideration.

THE CHAIRMAN (Mr. H. Giblin, Chairman of the Society's Council) said that while one of Cllr. Blewitt's points had not been for the speakers to comment on, he personally promised to raise the matter in the appropriate Committee of the Society's Council. However, Cllr. Blewitt had raised an interesting point that he wished to put to the speakers. He wondered whether they had, in relation to long-distance pollution, come across the effects of stubble-burning at all in their tests; and whether they could say what sort of distances the smoke from stubble-burning travelled.

DR. KALLEND said that it was an interesting question as, during the last flight they had done in the aircraft, the main visible emissions had been plumes from stubble-burning. Not only had they been visible but each time the aircraft had traversed such a plume, during a transit across Lincolnshire and Bedfordshire, the sulphur dioxide had been easily detectable. On other occasions he had observed stubble-burning plumes well out to sea. In principle, there was no reason to doubt that such emissions could travel long distances. Its importance to long range transport had to be judged in relation to the extent of those emissions compared with those from major sources.

DR. BARNES said he would certainly accept that. He had seen plumes from stubble-burning well out into the North Sea, when he had been travelling by air. From the theoretical point of view there was no reason why the ash from stubble-burning would not behave in the atmosphere in the same way as the friable material emitted in the brown coal areas of Central Europe. In his own monitoring he had certainly picked those latter emissions up on the coast of the United Kingdom. Moreover, he thought that although the actual combustion was taking place at the surface, one could certainly observe the very intense thermal rise that was developed during stubble-burning such that the plume, on many occasions, rose just as high as if it had been emitted from a tall stack.

But he wished to add just one comment, for the benefit of the learned Councillor. Dr. Barnes said that he lived in the country and many of his friends were farmers. He thought that their attitude was that stubble-burning caused as much difficulty to them as it did to people who did not farm. If farmers were not to stubble-burn, then they would have to use some alternative method of killing the weed seeds, fungi and pests that would otherwise persist through the winter period. He wondered whether it was desirable to replace having an intense fire over just one or two days with adding yet more chemicals to the environment.

DR. IRWIN referred to a study involving simulated burns and field trials which had been carried out by Harwell 2 years before, to examine the formation of the carcinogen benzo (a) pyrene during straw-burning. They had found that the total amount of benzo (a) pyrene emitted during straw-burning in the United Kingdom was of the order of 1% of the total annual emission but local concentrations in the period immediately after the harvest had not been established.

CLLR. BLEWITT said that what was forgotten was that the social impact of stubble-burning had not been thought of in relation to smoke control areas, but twenty years later the impact was so great that its disadvantages to society, to people and to animal life outweighed the help it gave to the farmers. Originally, stubble-burning was done by farmers to try and get a second crop for the winter. With all the modern aids and as a result of pesticides etc., the adverse effects outweighed the benefits and therefore he was asking that there should be a rather severer restriction on smoke, that the farming industry should be brought into line on smoke emissions like everybody else.

COUNCILLOR DR. MALCOLM FOX (Leicester City Council) had three comments or questions on the two excellent lectures. Referring to comments made by Dr. Barnes in relation to the slides shown earlier of pollution in Czechoslovakia, Dr. Fox mentioned his own experiences in Poland the previous September going from Warsaw to Gdansk and being allowed to return! He had gone expecting to find a much cleaner society than he had. A young militant in his local party had assured him before he had gone that pollution did not exist in a truly socialist society! On his return, Dr. Fox had shown him the slides that he had brought back, and had been accused of having been biased and picked out the worst examples. Dr. Fox had said in many ways he was grateful for having been able to go to Poland and take the photographs. On that visit, there had not been quite the usual security problems because of what had been going on at the time. Dr. Fox said that he had used his slides to show his students what Britain had been like 30 years before; pictures of thick, oily plumes coming from district heating scheme chimneys, power stations, and buses - which did not really need to indicate that they were leaving a bus stop because a jet of black smoke came out from the exhaust pipe. There had also been a proliferation of two-stroke vehicles, all revving up at the lights, giving rise to astonishing clouds of blue smoke.

Pollution control in Poland was of a very low order. It was not part of the public or political consciousness there and the point of his first comment or question was that Dr. Barnes' and Dr. Kallend's work had shown that in some instances pollution was transported internationally. In that situation, people in the UK were in the same boat as some district councils had been 20-25 years ago; they had made tremendous strides in air pollution control but the district council next door and upwind had not, so they had not seen very much benefit from their efforts and expenditure. He thought that possibly a continental role for the Society might be, in association with other Societies in the west, to increase the perception of the pollution problem in the Eastern Bloc countries. Obviously the Eastern Bloc should control their pollution for their own benefit, but we should also try and get them to improve their pollution control for our benefit.

Dr. Fox's second comment, or question, was to Dr. Barnes and Dr. Kallend together. As an analytical chemist - or part analytical chemist - he had been very interested in some of the results for the sites and the sudden change which had seemed to occur at the end of the 50s and the beginning of the 60s lead him to ask them to comment on the quality of the results. If there had been such a sudden change, it struck him that there might have been a change in the analytical procedure. He well remembered a paper by R. S. Scorer which had analysed some of the results and which had shown, for example, that one meteorological station in Europe, which would be nameless, only seemed to get a rainfall in full bottles, and another place had consistently given results with a decimal point displaced. One decimal point to the right had distorted the initial contour maps. He hoped the speakers would comment on the quality of the work, of the end results, on which so much work had been expended.

His final question was to Dr. Kallend. He had been fascinated by the flux profiles of the plumes, and he thought that for perhaps the first time it provided for a test of the emission flux models on which various comments had been made earlier. It seemed to him that the distribution had not been Gaussian, more Lorentzian, sharper peaks superimposed upon much more flattened background, or much more in the wings of the distribution. He said that he would be very grateful to Dr. Kallend for any comments that he had on the actual shape of the fluxes which he had measured, very interestingly at such long distances from the original source.

DR. KALLEND said that, as far as the analytical quality of the data from the European Atmospheric Chemistry Network was concerned, Dr. Fox had quite rightly stated that Scorer and his former research student Patterson had examined the quality of the data in some detail and they had pointed out inadequacies. It was certainly the case that the analytical procedure for determining sulphate had been changed about the time that the sharp increase had been seen, but he could not honestly say - and obviously it had been something that CERL researchers had looked into - that they suspected that it explained the jump that had been observed in those data. However, if anyone was interested, Dr. Kallend advised them to read the papers by Scorer and Patterson, which were quite enlightening.

As far as the flux profiles he had shown were concerned, he obviously had not had time to go through the vast mass of data that CERL had, but on that particular flight, the situation had been somewhat unusual, and indeed they would not normally have expected to get such a sharp profile of whatever material they were looking at - in that case it had been tracer, or sulphur dioxide - at that kind of distance. That situation had arisen, they knew with hindsight, because the airstream had actually been accelerating. The speed had doubled between the east coast of Britain and the west coast of Denmark, and the effect of that had been to sharpen up the peaks. So that explained why they had got such high concentrations on that particular day. As far as the actual shape of the profiles was concerned, sometimes they did see nicely shaped Gaussian peaks; on other occasions the cross-wind profiles were much less symmetrically shaped, and one of the things that had been discovered in that programme was how often the atmosphere did not behave in accordance with simple ideas. For example there might be a sheer of wind with height which could distort the shape of the profiles observed. Thus, even the way in which plume material was dispersed was sometimes much more complicated than the simple model of a uniformly-filled mixing layer that was normally used.

DR. BARNES said that one of the points he wished to take up, both in the context of Dr. Fox's question, and of Dr. Kallend's paper, was the step functions. Those were certainly explainable in terms of analytical procedure; from an analytical chemistry standpoint that was what might be expected. But in the context of the long range transport of air pollution, meteorological changes could be much more important. He was at that time involved with some work within Esso, looking at the sensitivity of LRTAP to different variables, and they had found that the influences of meteorology far outweighed anything else - emissions, atmospheric chemistry.

In the European Air Chemistry Network, there had been no inter-calibration, to his knowledge, between stations, and it was quite possible that some of the data could be seriously in error. It had certainly been the case that under OECD, when inter-calibration exercises had been conducted, a small number of laboratories had not been coming up with the sort of results that they ought to have been. So step functions could be real, caused by meteorology, or they could be analytical.

What had to be faced, however, was that irrespective of whether there had been a trend in recent years, or not, the present pH of rain was generally accepted to be much lower than it ought to be. So the fall in pH must have occurred sometime, and there was no viable alternative theory at present for the pH being as low as it was, except for its depression by man's emission of acidic gases into the atmosphere. The fall in pH could well have occurred before the turn of the century; simply having a snapshot of the previous twenty years, when perhaps climate had far outweighed emissions in determining trends in pH, confused also, perhaps, by analytical mistakes, was an inadequate span of time to identify if and when man's impact had begun.

Dr. Barnes said that he had been asked another question, in the context of Eastern Europe, but could not recall exactly what it was.

THE CHAIRMAN said that the question had been whether there had been an increasing awareness in the Eastern Bloc countries. Dr. Barnes had shown two locations, in East Berlin and in Poland; he was asked to explain whether the Eastern Bloc countries joined in with the surveys etc.

DR. BARNES said that his personal feeling was that the Eastern Bloc had joined for political rather than environmental reasons. They had been quite enthusiastic at one point to participate in the inter-collaboration between West and East, when Jimmy Carter had been saying that the Eastern Bloc was failing to implement the Helsinki Agreement on Human Rights, because of the situation with respect to dissidents. One of the other agreements that had occurred in Helsinki was to collaborate on air pollution - and, because of their involvement in that issue, the Eastern Bloc countries had been able to say

'Wait a minute, Mr. Carter, we are implementing the Helsinki Agreement. What about our substantial collaboration on LRTAP?' But when it had come down to the nuts and bolts of information exchange and providing emission inventories, they had not been so enthusiastic.

He thought that the population in the Eastern Bloc countries he had visited were exposed to air pollution rather than aware of it, because they did not know any alternative. Although there were claims from the Eastern Bloc countries that they put environmental quality very high those were, on the whole, hollow sounds. In practice he had come across a lot of horror stories in the context of industrial operations in Poland, for example, where a certain town, the name of which he could not recall, was notorious in the region for having people with very low IQs, though the locals did not refer to it in that way - he thought that the English translation would be 'dumbos'. Visitors intending to go to this town were warned very much against it, because the region as a whole knew that there was something very odd about the people who lived there. Those people depended for their livelihood on a major leadworks!

THE CHAIRMAN had a supplementary question, which he thought might be appropriate. He asked whether, if there were readings from sites in Eastern Bloc countries (if they had joined in the survey), Dr. Barnes thought that they would affect his own readings at the present time.

DR. BARNES was not quite sure what the Chairman had meant in the context of reading. He said that better input data to the modelling exercises would certainly make the picture much clearer. It was possible to make some informed guesses, based on the fuels at the disposal of Eastern Bloc countries, their claimed economic productivity divided by an appropriate factor (they often claimed their productivity was considerably greater than it was in reality) and the fact that their fuels were of a much poorer quality than they would like them to be. The fuel quality data had been obtained before the Iron Curtain came down. For example, the Institute of

Geological Sciences had some interesting analyses of Eastern Bloc coal and those suggested that it was very high in sulphur. So one could get to perhaps within a factor of two of their true emission. On that sort of estimation, the Eastern Bloc was an important source, possibly emitting twice as much sulphur as the whole of Western Europe put together!

DR. IRWIN, commenting on the sampling and analysis of rainwater, said that pH itself was in fact very difficult to determine accurately as everyone was probably aware. Certainly in the inter-comparison exercises in the EMEP project, an improvement had been seen in the analytical standards of those laboratories which participated regularly.

One other possible explanation of the sudden change in sulphate concentrations observed at many EACN sites in the mid-60s might be a change in sampling method. The composition of a collected rainwater sample was influenced by many factors including the height, exposure and material of construction of the gauge and it was worth noting that several types of sampler had been introduced at different times during the EACN programme. What was surprising was that this step change had occurred at the same time at so many sites.

MR. J. J. BEAGLE (London Borough of Hammersmith) said that Scandinavia had always been associated with cleanliness in many aspects of their economic and social life. He asked the speakers whether the discovery, exploitation and development of the Norwegian oil field had led to any Norwegian oil refining or petrochemical or other industry and whether that had any effect in Sweden upon the acidity of water in the lakes or in the air.

DR. BARNES said that the answer was simply that, if there had been any contribution, it was insignificant.

DR. KALLEND said that local sources certainly could have local effects even in Norway or Sweden. An example was the smelting works at, he thought, Kongsberg just east of

Oslo, which according to his own observation, emitted a level of black smoke which would not be tolerated in the UK - and within an area of outstanding natural beauty as well. But taking the region as a whole then the OECD study had shown that Scandinavia came off fairly badly compared with, say, the United Kingdom in terms of the amount of sulphur deposited in comparison to its own emissions.

DR. L. E. REED (Chief Alkali and Clean Air Inspector) said that he was talking not as Chief Alkali Inspector because he had only been in post 5 days, but because in the past he had been closely involved with the subject of long range transport through OECD and the ECE. As Dr. Barnes had said, the European monitoring programme (EMEP) had arisen out of the Helsinki agreement as an area of co-operation between east and west. In that light, it had been very successful. Both Western and Eastern European countries were now making the same measurements often with the same type of equipment and producing results which were reliable. Thus, there was now common basic scientific information but he warned delegates not to expect too much from it. There were still too many unknowns and uncertainties to be able to indicate, other than on a broad basis, the link between the originators and recipients of acid rain. But even that showed a remarkable degree of co-operation between European countries.

The question had also been raised of the need for a lot more monitoring of other contaminants and colleagues on the platform had indicated support for that. Dr. Reed was sceptical about further monitoring on an international scale until the objectives had been defined. It was all too easy to acquire large amounts of data, the quality of which might not be too good, and then try and distill out from that what was happening on a continental basis. He thought it was preferable to back the sort of exercise that CERL were doing, where one group was studying in detail particular processes in the atmosphere. Something was far more likely to come out of that type of programme than a widespread monitoring scheme.

He thought that everyone had to recognise that the ball park on long-range transboundary air pollution had changed over the previous ten years. As Dr. Barnes had pointed out in the introduction to his paper, the subject had been barely recognised that time ago. There was now a Convention on the subject under the ECE and political recognition of the problems caused by transboundary pollution was now a fact. Technical solutions were still not easy but it would be recognised that over the past five years control technologies for sulphur oxides had moved appreciably forward. It seemed likely that, in the future, both of those two factors would weigh more heavily than they had done in the past.

Dr. Reed concluded by asking a question, which he thought was of some relevance. Dr. Barnes had pointed out that changes in fuel mix would have changed emission patterns possibly over the past decade. It was Dr. Reed's understanding that the change in fuel mix, or at least the swing back to coal, was likely to be very much greater in the North American Continent than in the UK and much of the US coal had a high sulphur content. If things went as he thought President Reagan would wish in terms of economic growth and reliance on coal, there was likely to be a much greater emission of sulphur oxides from North America. It was already known that long-range transport in fact took place across the Atlantic. He asked the speakers what they felt would be the effect on deposition patterns in Europe if there was a major increase in sulphur emissions in North America.

DR. BARNES thought that Dr. Reed had made some very interesting points leading up to his question, particularly his reference to the fuels mix, and to the forecast growth in emissions. At a recent meeting where atmospheric chemists and modellers had been arguing about the growth in carbon dioxide emission and how dramatically it would change the climate, it had been sobering to point out to them that they were basing that growth in carbon dioxide emission on the same data source as we based the predicted growth of sulphur dioxide and nitrogen dioxide emissions. And that was on energy forecasts that were based on economic growth rates which, in turn, were usually a reflection of political optimism; he thought it was fair to say that the international energy industry did not envisage the same growth in demand that perhaps the politicians hoped for.

In terms of the difference in hard coal between Western Europe and the United States, what Dr. Reed had said was certainly very true. The Americans were undergoing a lot of heart-searching about whether to exploit more of their indigenous oil supplies or whether to burn more high sulphur coal. The US did of course have some low sulphur coal, but it was not easily mined by opencast techniques and hence the poorer quality, high sulphur coals would be the ones to win in the marketplace. There was pressure, of course, from the Canadians for the US to control emissions much more substantially than they were doing at present, but certainly President Reagan did not seem inclined to bow to Canadian demands or indeed to internal pressures.

As Dr. Reed had said, transport in small quantities of sulphate into Europe from North American sources had already been seen. Dr. Barnes had been interested to see recently some of the German work which found transport of SO_2 also into Europe from the United States. In terms of the impact of even the worst scenario, of substantial conversion to coal burning in the United States, Dr. Barnes said it was very difficult to give anything more than an educated guess on the impact of the consequential increase in sulphur emissions. To date, their contribution to Europe was trivial compared with local emissions; he suspected that that would increase with increasing emission in the US; whether or not it would be proportional to the increase in emission, he could not say. He still thought that it would be small compared with emissions within Europe, particularly taking into account the fact that the Eastern Bloc countries were almost certainly going to increase their emissions very substantially. Therefore he concluded that even the worst change in the US could well be lost amongst the more likely increase in Eastern Bloc emissions.

DR. KALLEND agreed with Dr. Barnes; it was simply impossible to predict what kind of change in deposition that would produce in Europe. By way of illustration, he referred to the slide he had shown of sulphate deposition at particular sites in Europe, and said that delegates might recall that deposition actually went down in spite of emissions increasing. The sulphur that was emitted obviously had to go somewhere and, as Dr. Barnes had said earlier in the discussion, it was simply changes in meteorology which were by far outweighing, or hiding, the effect of the increases in emissions. Since those changes in meteorology that appeared to last for several years could not be predicted, he did not think it was possible at the present time to predict what effect an increase in sulphur emissions in the USA would have in Europe, except to make the kind of educated guess that Dr. Barnes had mentioned.

MR. A. J. CLARKE (Head of Environmental Section, Central Electricity Generating Board) said that he found Mr. Beagle's question interesting because it was something others in the CEGB had been looking at and he thought that their findings might be relevant. The actual production statistics of Norwegian industry had been examined and they were quite startling. Admittedly, the country had been occupied during the war, and for many years afterwards their economy had been extraordinarily depressed, but it had recovered in about 1955, since which date the production of many primary products such as iron and steel, metals such as nickel, and production of cement and fertilizer, had grown by 1000%. That was an astonishing growth rate, and the influence of North Sea oil had probably been slight because it would only just be coming into effect in boosting the Norwegian economy.

A study of the emission rates per capita in various countries showed that Norway's emission of sulphur dioxide per head of population was higher than that of the UK (which was in fact one of the lowest in Europe). The emission rate per capita in Canada was also higher than UK. Mr. Clarke felt that, despite the totally different nature of the countries, Canada and Norway, the common causative factor was the vast amount of smelting done in each country. That could by no means be used to blame Norway for their own pollution, because many of the smelting complexes were in the far north of Norway, far removed from the area which was said to be affected by the acid rain. It was important to bear in mind that that area was a relatively small one, in Norway's southern peninsula.

One of the aspects under consideration had been the fact that there were measuring sites for the European Air Chemistry Network in various places in Norway, many of them at the bottom of steep valleys where many of the industries were situated. There might be an accumulating effect from the topography which was making their own contribution relatively more important than it would have been if the country were level. Some work had been undertaken in the wind tunnel on dispersion into valleys, and some figures had been found which tended to confirm that this might be happening; a quantitative estimate had not been made, but the question was still open and possibly one of the remaining questions in the acid rain situation was whether the cumulative effect of local emissions in the valleys was in fact having a disproportionately high impact on the actual measurements of water chemistry made in that country. Mr. Clarke invited comments from Dr. Barnes and Dr. Kallend.

DR. BARNES had been going to raise that point. Certainly, in terms of specific monitoring sites in Norway that were situated in valleys where there was industry, then the information collected from those sites would be heavily biased by the industrial activity taking place in the same valley, particularly when the mixing height fell below the height of the surrounding mountains. He thought one got a much more objective view of what was happening on an international scale in Norway by taking a look at the data from those sites that were located in valleys which did not have industry. Some of them did not in fact have any settlement and many of them did not have any roads either. He thought that it was those very remote areas that were uninfluenced by local emissions that showed a much clearer story.

DR. KALLEND said that he had touched upon the effect of local emissions when he had talked about the data from the European Atmospheric Chemistry Network. One of the other things CERL had looked at in that data had been to see how valid it was to take data from neighbouring sites, and plot it on the same graph, as it were. So they had looked around amongst those 120 sites (in the whole of Europe) for a group of local (neighbouring) sites, for which there was enough data over the years to compare. The sites had: first of all to have had data over a sufficiently long period of time and, secondly be close enough together, i.e. within 20 km of each other. For a group of four sites around Stockholm, they had found that two of the sites correlated fairly well together, the other two sites correlated fairly well together, but the two pairs had not correlated at all. In fact, one pair had shown a trend of increasing acidity over the years, and the other, a trend of decreasing acidity. It was that kind of observation that made him think that local effects might be quite important in determining the precipitation composition in parts of Scandinavia. Some people had argued that it did not really matter whether there were trends, and that all that mattered was that precipitation now was acid. If that was the case, then the argument had changed, because certainly to date a major part of the acid rain story had been that there was the trend of increasing acidity in precipitation and an expanding area receiving acidity.

DR. BARNES, taking up the point about major changes in the story said that, looking back ten years, there had been a total revolution. He had not had a chance in his talk to compare some of the claims that the Swedes had made early on, with what was generally accepted now. He thought that a major revolution had occurred in terms of the claims with respect to forest productivity, which had always been a cornerstone of the Swedish demands that emissions should be reduced, because both Norway and Sweden depended very heavily, in economic terms, on their forest productivity. He had been very pleased to see in the final report of the SNSF study, published in 1980, a categorical statement that, if anything, the contribution of nitrate into an otherwise nitrate-deficient environment actually enhanced forest growth. That in itself was a revolution. There had been others, and he thought that the present disagreement between those, even within Scandinavia, who believed that the acidity of rainfall had increased recently and was a fundamentally post 2nd World War phenomenon, and those, also in Scandinavia, who thought it dated back a lot longer, was another example.

DR. IRWIN wished to emphasise that it was most important to obtain site descriptions, if at all possible, when considering the results from any monitoring network.

MR. H. I. FULLER (Individual Member) said that, as some present might know, he had been involved with the subject of LRTAP for some years and consequently had a little bit of a background; he had however found it very interesting to hear some of the more recent thinking that was going on.

He had been listening to try and find out where we stood. It seemed to him that there was uncertainty about the increased acidity of the rainfall. There seemed to be some uncertainty as to whether it was sulphur or nitrate or something else that was causing the changes. There seemed to be rather less uncertainty that the lakes were becoming fishless and lifeless. Nevertheless, if one pursued the thinking of Dr. Reed that there were political pressures for change, for improvement by reducing emissions of sulphur, he was interested to hear from the speakers whether they could give an estimate, a guess, an order of magnitude impression of what was the damage, what were the costs of the alternative remedies. He asked for some idea of the amounts of money that would be involved were action to be taken.

DR. BARNES remarked that the cost of damage was of course a most difficult question. Just looking at lake fishlessness as an example, he would take a fairly simple sort of economist's view and approach the problem from the point of view that certain lakes that had had recreational value no longer had that value, that the peole who used to travel to them to enjoy fishing, or looking at the fish, or whatever other recreational values there had been, now had to travel further afield, spending more time and more of their petrol in doing so, and therefore incurring greater costs to participate in their chosen recreation. An extreme view, that he had seen in a recent OECD study on the costs and benefits of sulphur dioxide control, had been to assume that all the lakes, now fishless, had been in commercial trout production, taking the value of the trout that they would have been producing, notwithstanding the fact that the majority of lakes in southern Scandinavia were totally inaccessible, and that if there had been production, the fish would undoubtedly have been stale by the time they got to market. Then, of course, there was the alternative view that one could not cost leisure or the quality of life. The difficulty of the position in terms of damage costs could therefore be appreciated.

Dr. Barnes said that he had one or two numbers with him that related to costs of abatement. Some estimates had been made of what it would cost to lime the whole of southern Scandinavia. That was not just using the fairly cost-effective approaches he had shown that morning - bringing a lorry in and squirting the stuff on to the lake, or using lime wells - but the estimates in fact took into account that some of the very inaccessible areas would have to be limed by helicopters and so on. The most recent estimate, perhaps two or three years old, suggested that a figure in the region of US$ 150 million per annum would suffice for southern Scandinavia. At that time the Scandinavians had been suggesting that the problem could be solved by a 50 or 60% reduction in European sulphur emissions. It was still not clear whether that would work, of course; it could only be certain to work if emissions were to be eliminated completely. At any rate, that 60% reduction would have cost, at that time, something in the region of US$ 10,000 million (or 100 times as much as liming) even using the most cost-effective combination of techniques. That combination would include the use of high sulphur coal in power stations and scrubbing the stack gases, expanding nuclear power generation and energy conservation techniques and supplying small industrial and domestic consumers with desulphurised oil or natural gas.

The problem, however, was not simply emissions; it was also sensitivity of environment. Dr. Barnes felt that that point was often lost. One could either treat the receptor, which was very localised, or one could treat the manifold emission sources across Europe.

DR. KALLEND thought that perhaps Dr. Barnes was being a little coy about his own calculations because he had been going to refer Mr. Fuller to Dr. Barnes' paper. There had been many estimates of the cost of limiting sulphur emissions. CERL had of course done its own. The NATO CCMS working group, about a year previously, had produced a report costing flue gas desulphurisation, for example, as a way of cutting down transport of sulphur long distances. As to what effect a hypothetical reduction of sulphur emissions would have, some people had attempted to relate changes in total emissions quantitatively to expected consequent changes in lake and river chemistry. However, so many assumptions had to be made or were implied in such calculations that his own view was that they should be treated with extreme caution at the very least.

DR. BARNES thought that the question of remedies had been looked at very simplisticly and perhaps from polarised positions. One extreme was to cut emissions across a wide area dramatically, which would be very expensive; the other extreme was to do nothing, or perhaps lime certain areas. Politicians now needed to get together in a more objective fashion and identify an optimum combination of techniques which could well involve some liming, some emission reduction, change in fuel balance, more energy conservation, more nuclear power. There was a whole range of alternatives which could ameliorate, if not eliminate, the problem. He did not think that it really helped to stand in extreme corners and say that emissions had to be controlled entirely, or that nothing would be done until it could be proved Norway was dissolving.

SESSION 6

BRITAIN'S NUCLEAR FUTURE

PLANNING OUR NUCLEAR ENERGY FUTURE

Michael Gammon, Generation Development Engineer,
Central Electricity Generating Board

NUCLEAR POWER - THE PROBLEM OF PUBLIC ACCEPTABILITY

Robin Grove-White, Director, Council for the
Protection of Rural England

DR. CLELAND McVEIGH (Head of Energy Studies, Brighton Polytechnic), opening the discussion, said that it gave him great pleasure to be invited to talk to an NSCA Conference once more. He had previously discussed solar energy and related topics some five years before at the 1976 Edinburgh Conference. He spoke as a professional chartered engineer, holding engineering degrees from three British universities and as one who had made energy a particular study over the previous 20 years. Like a good academic, he drew the audience's attention to two publications, one of which he had brought with him, called "Nuclear Power and the Energy Crisis" by Duncan Burn, published by MacMillan Press, 1978. He explained that that particular book described very clearly, and with a great deal of reference material, the history of the Atomic Energy Authority's involvement in the UK. The second book he recommended was a study by the Swedish Futures Studies Secretariat, called "Solar Versus Nuclear", published by Pergamon Press, 1980. In that study, an independent group who reported directly to the Swedish Prime Minister's office concluded that it was not possible at present to say whether or not a nuclear future or a solar future would be the most economic for Sweden to adopt. Many of the lessons revealed in that book could be applied equally to the UK.

Before he came to the main points of his brief comments, Dr. McVeigh wanted first to talk about waste disposal. Some 30 years earlier, Cockcroft had first said to the 4th world power conference "Waste disposal must be recognised as a very grave and serious problem which we must solve". 30 years on, there was still no solution.

Robin Grove-White had pointed out that over-estimated demand had been a feature of the CEGB's planning in the past two decades and had, in Dr. McVeigh's view quite rightly, said that we had the largest over capacity in the western industrial world: the UK had far more electricity available than it could use. Dr. McVeigh said that distorted the economics because the CEGB ran their coal stations as a spinning reserve. They were not generating anything but were still burning coal.

Dr. McVeigh's third point was on job creation, which had not been touched on at all by the speakers. There were in existence quite a number of independent studies, the most recent being from the Institute of Applied Mathematics in Paris, pointing out that having a nuclear industry to create supply would involve far less total jobs over the long term than a different set of options, particularly a solar and renewable and conservation type of option. With the last, the same amount of money was spent, and the number of jobs involved was something in the order of three times greater. Dr. McVeigh admitted that that sort of analysis had been hotly attacked by an Aberdeen University research group, backed by thousands of pounds of research funding compared with practically no money spent on groups putting forward alternative views.

Turning to economics, Dr. McVeigh referred to the history of the Atomic Energy Authority which he said was full of promises which had sadly been proved to be hopelessly over-optimistic. To illustrate this, he quoted from the Minister of Power in 1965, when telling the House of Commons about the decision to invest in the advanced gas cooled reactor programme: "We have made the biggest breakthrough of all time; we have hit the jackpot this time". But there had not been one single overseas order. Referring to the table on page 20 of Mr. Gammon's paper which showed a typical timescale for power station planning, Dr. McVeigh pointed out that when capital investment approval had been secured, there appeared to be another 6 or 7 years to the year of commissioning. However, in practice, of the UK's five gas-cooled reactors, three had not yet been completed; Dungeness B was now in its 16th year, Hartlepool in its 13th, and Heysham in its 11th year since the initial planning approvals. Pointing out the economics of that sort of timescale, he said that as far back as 1975, it had been estimated that the advance gas-cooled reactor programme had cost some £4,000 million (1975 £s sterling). In today's terms, that was £8,000 million, but of course also to be taken into account was the interest on the money that had been spent by 1975 - clocking up at whatever particular interest rate it was convenient for the Government analysts to put in. That was why the economics of nuclear power were always so difficult to follow.

One simple thing that could be examined was the capital cost per installed kilowatt of power. In that regard also, Dr. McVeigh felt that the way in which the economics had been followed out historically was very misleading. The Magnox power plants had been based on having 70% capacity; in other words, they were intended to work for 70% of the year at the design capacity, or planned load factor. However, all Magnox reactors had been down-rated in the early 1970s because they could not produce the power. In other words, their capital costs had effectively doubled, when other delays and increased costs were taken into account. And there was no evidence, other than that historical record, for thinking that any future programme would be any different.

Turning to the point made by Robin Grove-White, related to the openness of the sort of society that would be emerging, Dr. McVeigh wondered where all the bright young men who would be required to work in the nuclear industry would come from. This was, he felt, a very serious problem. One of those men had spoken to him recently, and had said, "I was thinking of a career in the nuclear industry and, when I asked them what I would be working on, they couldn't tell me. When I said, 'supposing I don't like what I've been doing after 2 years and wish to leave, what can I tell a future employer about what I've been doing?' - 'Oh, you can't tell him anything about that; that would be a breach of the Official Secrets Act'". So that young man had said "Well, that is not an industry that I want to work in". Dr. McVeigh believed that increasingly young people would not wish to commit themselves to that sort of a future.

On renewables, Dr. McVeigh remarked that the establishment frequently stated that renewables would not contribute very much to the United Kingdom's energy supply in the immediate future or even by the turn of the century. In the 1950s and 60s, there had been a hundredfold disparity between the amount of money spent on nuclear research compared with the renewables and all the rest put together. Even now there was a tenfold disparity. He said that the sort of sums done by the Department of Energy in assessing renewables were extraordinary. On the wavepower programme, for example, Salter in Edinburgh University had shown that the calculations for simple metal weights used to hold down his wavepower devices in the estimates produced by the Department of Energy experts were such that he could buy brand new lathes from the Colchester Lathe Co., and sink his wavepower devices and hold them down to the seabed with the brand new lathes, because that would be cheaper than the simple metal weights suggested in the cost estimates of the Department of Energy. Dr. McVeigh had very grave doubts about the way in which they did their sums.

He thought that the demand side was again very interesting, because even official estimates of UK energy demand were falling as time progressed. They had gone down from 600 - 550-500 million tonnes of coal, and could now be prepared with the actual (present) level of demand, of about 340 million tonnes of coal equivalent. With the many other developments in electronics and more efficient electric motors and machines, it was extremely unlikely that electricity demand would rise, if at all, over the next 20 years. Some, Dr. McVeigh among them, had been saying that for quite some years, and he thought it was interesting that many other well known and respected independent research bodies were now coming to the same conclusion.

Dr. McVeigh ended his remarks by quoting from a former chief scientist to the United Kingdom Ministry of Power, Sir Kelvin Spencer: "The conclusion I've come to in my old age is that most of the troubles the nuclear adventure has run into, an adventure which started with such high hopes, arise from the dominant position that experts have won in its affairs. Such people, as a consequence of their expertise in a very challenging subject, are technically oriented to the exclusion of the wider vision. Reference to "Who's Who?" shows how many of those high in the nuclear energy hierarchy have been educated and spent all their professional lives in the narrow rut of one intellectual discipline. This is not a satisfactory background for those in control of a large and vital industry that affects us all and our descendants for untold generations ahead. As Lord Salisbury said, when Prime Minister, in the heyday of Britain's greatness, "Never trust the expert; he's sure to be wrong"."

MR. NORMAN JENKINS (Journalist, and specialist in international energy strategy) said that he was by no means an expert so that his words would perhaps carry the worth that Sir Kelvin Spencer had referred to, when he had said, "Don't trust the experts"! When Mr. Grove-White and, for that matter, Mr. Gammon, had referred to combined heat and power (CHP), he had wondered how many in the hall really understood or appreciated the significance of that technique ... how many people really fully appreciated the complete alternative CHP offered to nuclear generation. Leaving aside any question of production of plutonium by the nuclear reactors used for power generation there was only one purpose for nuclear energy - the production of electricity.

Whatever the fuel from peat to nuclear, CHP produced usable energy in only a slightly different way but one that was far more economic, one that produced even cheaper electricity than nuclear power.

In the conventional, solo, generation of electricity, trainloads of coal operated merry-go-rounds from pit to power station. Two out of three of those trainloads did no more than produce quite useless heat. Nuclear power stations did only a little better.

CHP made use of that otherwise wasted heat. The amount of expensive electricity produced was necessarily less but that was all to the good. In every area where CHP operated, far less electricity and gas were needed; hot water distributed by networks of thermally insulated pipes took the place of electricity and gas used for space and water heating. There were a few - some five or so, small CHP areas in the UK, some 3,000 in non-communist Europe, probably double that number in the USSR. CHP as a technique now had Federal support in the USA. In the UK there was an official programme of investigation which was no more than a delaying tactic.

Reflecting on who had initiated that delay and why, Mr. Jenkins referred to the statement made a year before by a senior civil servant of the Department of Energy, Mr. Peter Jonas, at the Institution of Electrical Engineers Conference on CHP, November 1980. He had said that while CHP had its friends, it also had its enemies. Mr. Jenkins wondered who those enemies were, why they were so adamantly opposed to CHP, and why they created what had for so long been recognised as institutional and political obstacles to CHP. When, in a committee of the District Heating Association, he had endeavoured to persuade his colleagues to seek an official answer from Mr. Peter Jonas or his department, he had been silenced. The debate had been closed by a motion of the representative of British Gas and seconded by the representative of the CEGB. That was a matter of record.

Turning to the official inquiry that was going on into CHP, Mr. Jenkins said that in 1974 a committee had been set up under Dr. Walter Marshall (now Chairman of the UKAEA). That committee had finally reported in 1979. The Marshall Report had recommended a two or three stage inquiry to see whether one town or city could be found for a justified experiment in CHP. Mr. Jenkins asked delegates to bear in mind that there were 3000 networks in Europe alone supplying perhaps between 3 and 15 million satisfied consumers.

The Marshall Committee had been almost wholly comprised of representatives of the established energy industries, their suppliers or their advisers. Acceptance of that report showed the Government to be naive - as naive as the population that also accepted pleas from the nationalised industries that all was well. They said that no drastic changes in direction were needed; they ignored the continuing and sharply increasing fuel crisis.

He wondered how anyone could accept what those same industries asked them to believe if what the public wanted was against their interests; could they really be expected to promote combined heat and power when, even in the smallest such installation, let alone nationwide use, those same industries must inevitably step down to subordinate roles, providing only contributory services, surrendering their present domination of the whole energy scene.

If that situation was considered carefully as one of fundamental fuels exploitation, the sheer necessity for maximising the energy produced from fuel, it could be seen that of the two simple components of energy that were required, heat and power, heat was by far the most important. Electricity, even now, was as it always had been, a by-product of heat. To ensure the least possible waste of any fuel, it was necessary to start again - at least in national intention: no large scale heat plant ought to be operated without the by-product generation of electricity.

That was precisely what the new Federal law in the USA meant with its organised encouragement of 'dispersed generators'. Breaking the CEGB monopoly in the UK meant the same thing: introduction of widespread CHP on a macro-generating and distribution basis. That meant that most of the 15 GW of electricity now targeted for nuclear power could be produced by CHP - for far less investment and indeed far less pollution than that produced at present. Each town and city based on CHP would have one chimney, one single set of flues for one single set of boilers - to control, not promote pollution.

Investigation of that claim would reveal that the reduction in electricity due to substitution of a distributed heat would be at least one third while the reduction in the use of gas would be the same or greater. However, Mr. Jenkins warned against expecting those two industries to produce any enthusiasm or even the slightest help to that end. There had already been far too many platitudes, and far too much lip service on the subject. What was needed to get swift and effective action was an effective and an entirely independent and unbiased set of experienced people to man an Energy Council to do for all fuels - impartially - what the Electricity Council had been doing in determining the UK's major energy policies on the mistaken assumption that electricity was of primary importance. Mr. Jenkins said that that was a grievous error of unimaginable proportion: it was not electricity but heat that mattered. Macro-generation of heat and power was the right answer; only a truly impartial Energy Council, to replace the Electricity Council, could determine the right priorities.

MICHAEL GAMMON, replying to the two opening speakers in the discussion, started with some very general comments. He thought that both Mr. Jenkins and Dr. McVeigh had really been making the point that experts could not be trusted, that those people who knew anything about the subject should be discarded, and that instead one should trust people's prejudices. He found that an extraordinary attitude, although, with apology, he was himself prejudiced. However, when examination was made of the way a system operated in the UK, while there were certainly experts, they were controlled by Parliament, and by other institutions basically controlled by democratically elected representatives, who in turn would rely on their experts. There was a great deal of control by people who were not experts in the particular field, who represented the widest interests and who had some exercise of common sense. He could only comment that the truth apparently was quite different from where Dr. McVeigh and Mr. Jenkins sat.

Mr. Gammon said that he had tried to interest local authorities and development corporations in a number of schemes for combined heat and power over the years. He had yet to find anybody who was interested at the price at which CEGB could offer them the heat. He thought that possibly the basic problem in the UK was that, every time, gas central heating won as an option. He warned against forgetting the difficulties inherent in introducing combined heat and power. He hoped that the government studies would be successful in designating at least one Lead City for CHP schemes. However, he warned that the disturbance and cost of digging up streets, of requiring people to connect, should not be forgotten; it was no use laying mains if most people were satisfied with their existing heating. If the exercise was to be economic, people had to be required to connect, as happened in most of the Scandinavian countries.

Turning to the question of construction times, Mr. Gammon said that the experience of the construction of the advanced gas reactors had been most salutory, and sad. They had taken years longer to construct than they should have done. Magnox stations used to be built in five years or so. The Americans, the French, and the Germans had built PWRs in the same timescale. It was to be hoped that the UK would be capable of doing such work in the future.

On the economics of the Magnox stations, he said that the original economics had been done on a 70% annual load factor and an assumed 20 years life. Those stations had been down-rated but they were now getting an 85% load factor on the de-rated capacity and they would probably have 25 years plus life. They had been, and they continued to be, economic.

He was astonished that anyone should suggest that young people who wanted a career in engineering or science should not come and work for the institution that he knew about - the Generating Board or the Electricity Supply industry. He said that they would not find secrecy and limitations on what could be said or written or told to other people.

One area where there might be secrecy could be in connection with national defence. He was certainly unaware of it being a general feature of either the UK AEA or BNFL, but again there might be situations where national or commercial considerations led to some restriction. However, that was not widespread and if any of the students present in the audience were interested in working for CEGB, he asked them to come and see him or one of his colleagues.

Turning to renewables, Mr. Gammon said that there were many alternative energies; there was solar, there was wave power, there was wind, there was tidal power, and the Generating Board had a responsibility to look after its consumers. If CEGB genuinely believed that it was possible to get cheaper or more secure supplies of electricity from any of those sources, then it was CEGB's duty to do it and he believed that it would be done. As it was, CEGB was keeping an option for those alternatives. R&D was going on in a small way; it was, however, no use comparing the amounts of money spent on such research: if equal amounts of money were spent on two things, one of which was a way-out chance, the chances were that a lot of money would be wasted. In CEGB's case, it was not their own money, it was the consumers'.

ROBIN GROVE-WHITE, replying on the question of CHP, said that there was a striking lack of symmetry in the way Mr. Gammon had approached the question. He had suggested that introduction of CHP systems in cities would involve intolerable burdens, impositions, on resident populations. The fact of the matter was that his own industry already had very substantial monopoly powers, to raise prices, to cut off and disconnect - powers which it used. It had a power of entry on to people's land; it was prepared now - and Mr. Grove-White said that he was not blaming CEGB for this, it was within its statutory remit - it was now going to the courts to ensure that it could go on to people's land against their will and in the face of the fact that the Chief Constable was not inclined to support it. That was the present position.

Undoubtedly, there were equally disadvantages that would result from the introduction of CHP. One paid ones money and one took ones choice. What Mr. Jenkins had said, and he would certainly support him on that, was that combined heat and power had not had a fair deal hitherto in Britain. It had not had a fair deal institutionally. A big factor in that had been the fact that CHP did not fit in with the priorities of the existing nationalised energy industries.

On the other question he had just one comment. Mr. Gammon had said that the CEGB had had a very sorry story over the AGRs and had now learnt its lesson. While that might be so, Mr. Grove-White said everyone was perfectly entitled to look at the Board's past experience on major construction projects when they came to appraise the credibility of its promises about its future performance.

MR. GAMMON remarked that CEGB did not manufacture and build nuclear power stations; that was done by British industry.

GORDON MACKERRON (Fellow, Science Policy Research Unit, University of Sussex) (Energy Policy Programme) said that, for Mr. Gammon's benefit, he could claim to be an expert! There were a number of points he wished to make, which mainly referred to the questions of forecast energy demand and the immediate need for nuclear power. The first was that the idea of an energy gap now seemed to be thoroughly discredited; the idea that nuclear power was needed, because without it, the lights would suddenly all go out, seemed to him to be frankly a nonsense. It was now well recognised that there was an enormous supply of coal in the world, quite apart from renewables, and while he agreed that those might be available only at ever-increasing cost, it seemed to him to be scare-mongering to talk in terms of an energy gap.

Secondly, moving away from the idea of an energy gap to the idea of the future needs that there might be for specific amounts of electric power, he thought that it was important to notice that the CEGB itself now no longer mainly justified nuclear power on the grounds that the UK would be short of electricity in some future planning year.

In its replies to some questions put to it by the Select Committee on Energy, to which Mr. Grove-White had referred, CEGB had said that it could justify new nuclear power stations entirely on what it called "net effective system cost grounds". Mr. Mackerron said that he would not go into the technicalities of that. However, very broadly it meant that even if there were to be no growth at all in UK electricity demand, nuclear power was supposed to be needed because it was so cheap that the cost of both running a nuclear power station and paying its capital cost would be less than just running an old power station at the bottom of the system.

If those were indeed the main grounds, as he thought CEGB now admitted, for wanting nuclear power, it threw a great deal of weight on to the precise economic costings attached to nuclear power. Because even if it was agreed that nuclear power was the cheapest of all the various options available, it meant that not only did it have to be the cheapest, but also that its total costs had to be less than the fuel costs of inefficient stations at the bottom of the system. Mr. Mackerron declared that he had been an adviser to the Monopolies Commission Report into the costs and efficiency of the CEGB, to which Mr. Grove-White had also referred, which was why he had a particular interest in the matter. However, he felt that it had been quite clear from that report that the CEGB had not yet made anything like a convincing case, on those net effective cost grounds, for ordering new nuclear power stations.

Referring to the Monopolies Commission report, he quoted from the section dealing with the CEGB's investment appraisal, which had said that the investment appraisals done by the CEGB on its nuclear stations were "seriously defective and liable to mislead". Insofar as those investment appraisals had been used to bolster the general national and strategic case for keeping the nuclear option open (which he agreed might exist) the Monopolies Commission had concluded that the appraisals might have given a boost to that case which was unjustified. If the assumptions which the CEGB itself used were changed only marginally - something the Monopolies Commission actually had done, it was possible to get very easily and very quickly from a situation where nuclear power was justified on those net systems cost grounds, to one where it was not justified at all. The kinds of changes in the CEGB's assumptions required were really very marginal indeed. It was necessary, for example, only to change its construction duration assumption from six years to seven years, and change its load factor assumptions from 65 to 64%; putting those historically plausible numbers through the CEGB's own computer would reveal that really nuclear power would not be justified on those grounds at the moment.

That being the case, and given the concerns that Mr. Grove-White had voiced about public acceptability, it seemed to him strange that the CEGB was therefore pushing ahead so quickly with new nuclear power stations, when on the one hand it admitted that on normal forecasting grounds, shortage of power in some prospective year was unlikely, and that on the other hand (if the Monopolies Commission were to be believed), the economic case for supposing the net effective cost to be negative was in fact extremely fragile. His own view would therefore be that there should be cause for some serious pause in the CEGB's planning on nuclear power stations, because it really had no imperative at all to go ahead and order new nuclear stations for some considerable time to come.

MR. M. GAMMON, replying, said he regretted that Mr. Mackerron still had the idea that CEGB was dashing madly ahead ordering 15,000 MW or some such figure of nuclear plus. About the earliest it would be placing the order for the next nuclear station, a modest 1,200 MW, was 1983. There was no commitment to placing the next one in the following year, or even in the year after that; as he had explained, CEGB looked at each of those proposals and went forward when it believed that one was justified. The Monopolies Commission had certainly looked at a number of variants, but the future was of course a matter of comparing costs from one source and another. He thought that if the Monopolies Commission's conclusions were examined, for all that they had said that CEGB had been too optimistic about the time taken to construct, that CEGB might be too optimistic about other factors (although overseas experience now suggested that if anything it was the other way round), if a modest increase in the price of coal, in real terms, was allowed for, then the Monopolies Commission's conclusion was still that nuclear power was cheaper than the alternative.

The idea that the energy gap did not exist he found strange. Mr. Gammon said he would try to quote some very broad figures. The energy demand in the UK was currently about 300 million tonnes a year (in terms of coal equivalent); of that there was about 120m tonnes of coal mined in the UK, about 150 m tonnes coal equivalent from oil, and about 30 m tonnes from other places, mostly nuclear power. He asked how long the country could continue on that basis, how long the UK would be able to rely on North Sea oil and gas. It was possible to import coal, but one would be talking in terms of importing in the order of 100 million tonnes a year. He did not believe that the economy would stand that; the UK would immediately be back into the most enormous trade gap. He agreed that the lights would not go out suddenly, but electricity would become more and more expensive, and there would be more and more problems with old people and the poor who could not afford it. He did not, as someone who looked after the consumer's interest, see that as an acceptable future.

MR. R. GROVE-WHITE, replying, said that he did not want to argue the toss with Mr. Gammon about energy policy questions; Mr. Mackerron could do that much better. However, he said that it was quite clear from abundant emerging studies that there was a colossal potential for more efficient use of energy through conservation measures, through insulation, and through more efficient boilers in industry. There were legion possibilities, many of which were already coming into operation on an ad hoc basis. He felt that Government could do very much more if it wanted, to encourage those sorts of processes. In the longer term there were other technologies which were less inflexible than nuclear power. The possibility of stabilising the growth in energy demand in the longer term was very substantial, so he did not think that it was necessary to accept the energy demand assumptions Mr. Gammon had been putting forward, which had in fact a rather pre-1973 oil crisis ring about them.

The other point he made related to the significance of what Mr. Mackerron had said about his role in the Monopolies Commission report. The significance of that to him was not that the Monopolies Commission was right necessarily, and CEGB wrong - but that there were now genuine intellectually grounded doubts about the economic prudence of the course that was being advocated by the nuclear lobby. Those doubts would emerge. They were not doubts that would just disappear; they would intensify. The greater the light cast on the programme and the technology, to his mind, the more inevitable it was that there would be difficulties in implementing it. He thought Mr. Mackerron's point had simply underlined that very simple proposition.

MR. M. GAMMON said that everyone should look forward to the inquiry into the first PWR, because that was the occasion when most such arguments would be dealt with in very great detail, when there would be a possibility to examine them and cross-question each other, and he hoped that thereafter they would come to some agreement as to where the truth lay, somewhere in between.

MR. R. GROVE-WHITE said that a point he had tried to make consistently in his presentation was that nuclear economics were dynamic - that they altered over time. That was plain from the historical record. They would continue to alter over time, and it would not be possible suddenly to say 'Right, that is the last word on nuclear economics: a future Monopolies Commission report, a future Select Committee on Energy report is not going to be allowed to influence public opinion any more'. It would! That was a simple fact.

MR. M. GAMMON said that we were living in a very uncertain and changing world, and that the economics changed in both directions. His guess was that the price of fossil fuels would go up far faster.

MR. ROD MARSHALL (Nottingham City Council, Environmental Health Department) asked whether Mr. Gammon and Mr. Grove-White had any observations on the recent declaration by Nottinghamshire County Council that the county should be a nuclear-free zone and whether they had any further observations on what the position would be if there were more such declarations throughout the country.

MR. M. GAMMON, replying, felt that it must be said to be an example of a local authority trying to dictate national policy, and he thought in that instance, "nuclear-free" meant "no nuclear weapons, no nuclear power stations, no transport of nuclear fuel through their area". Those were things which were, with the greatest respect, not within the province of Nottinghamshire County Council. They were however perfectly entitled to express a view and to make those views known.

MR. R. GROVE-WHITE was not sure quite what was implied by Mr. Gammon's remarks: he thought it was self-evident that Nottinghamshire County Council had a right to express a view; however, he wondered whether Mr. Gammon was implying that at some point they had to be stopped from expressing a view. His only observation was that that sort of activity, that sort of decision by a local authority (which was not alone in having done that - different people had different views on whether it made sense or not) was indicative of the difficulties that a nuclear programme would run into. It simply fed the dynamic he had described, of the sheer political difficulties of implementing that particular solution to energy problems.

DR. C. McVEIGH said that if Mr. Gammon examined the Department of Energy's own official energy predictions, and if it was assumed that the CEGB ordered its power stations year after year from 1983 through until 1993, then by the year 2000 he could assure him that nuclear energy would be contributing a very small proportion of the UK's total predicted energy demand. That was why he felt the UK's energy policy to be unrealistic, because there was still a large amount of oil, and a large amount of gas and a large amount of coal, available to provide the great bulk of the total projected energy demand by the year 2000. That was why people like himself were saying "For God's sake put the money into conservation, put the money into solar". Economic factors had been discussed, and since he had last spoken to the Conference in 1976, the price of photovoltaic cells for generating electricity had dropped in real terms by a factor of 20.

MR. M. GAMMON said that if CEGB got another 15,000 MW of nuclear power by the end of the century - and he hoped it would - that would be providing energy that would otherwise be required from other sources, somewhere between 35 and 40 million tonnes of coal. He believed that there were plenty of other people in the UK, industry as well as individuals, who would find that they wanted that coal before the year 2000, to take the place of oil and gas, which would either not be available, or would be too expensive.

MR. R. GROVE-WHITE said, in conclusion, that he thought there was an inexorable logic, of both political and economic events, that would tend increasingly to reduce the potential role of nuclear power. He said he would be very, very surprised if anything like the prognosis that Mr. Gammon had just made were to be realised in the year 2000. The discussion would have to be resumed in a few years' time.

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NUCLEAR POWER: THE PROBLEMS OF PUBLIC ACCEPTABILITY

by

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Mr. Grove-White's speech is published
here as delivered to supplement his
(pre-printed) summary paper

It seems to me that the public acceptability of nuclear power, which is the matter on which I've been invited to speak, is more than simply a question of getting people to see 'the facts' and to accept what the agencies responsible for the promotion of nuclear power believe to be the case. My feeling, having heard Mr. Gammon, is that his view of public acceptability implies just that. I think instead that the question one has to address oneself to is, can nuclear power be acceptable? - a rather broader question. The thesis I shall put to you over the next few minutes, and which I elaborated in note form in my paper, is that nuclear power appears to have characteristics which will continue to make it unusually difficult for the public, or rather the increasingly large sections of it who are now interested in such matters, to accept nuclear power at a scale of development which could make any major contribution to national energy supply in Britain.

I shall argue that nuclear development presents acute dilemmas for Britain's institutions. This is because the openness of these institutions - such conventional administrative apparatuses as public inquiries and parliamentary select committees - their democratic character if you like, exposes (and will continue to expose) the uncertainties inherent in nuclear power and will perpetuate them in a way that will make it increasingly difficult to get any substantial programme off the ground.

Now it's not for me to argue here the case for or against nuclear power; my organisation, CPRE, does not have a view on the merits of nuclear power as such, although we are deeply concerned about the Generating Board's inevitably growing appetite for rural sites if a significant programme should develop in future. Nor do I believe it would help our discussion if I simply argued a corner about the merits of nuclear power. I see my role in this discussion rather as trying to unravel some of the factors, from my experience within an environmental body, which will reverberate within the political and administrative system, to make difficulties for nuclear development.

May I make one preliminary point? Even if it were possible for the Generating Board and the Government to produce, let us imagine, cast-iron data that nuclear power was absolutely safe, unquestionably economic and utterly benign in every technical respect, in a society like ours where our institutions are open, that would be only half the battle. That is the problem of public acquiescence - to which Michael Gammon referred, himself. Part of my argument is that these very processes are likely to constitute an increasingly burdensome hurdle for the promotion of nuclear power on a significant scale, because the uncertainties inherent in the technology will become magnified under public scrutiny as developments are brought forward.

In the paper which has been circulated, I have instanced four particular areas of concern on which, in my judgement, the CEGB and the Government will face increasing public scepticism. The first issue is that of economics: Does Britain need nuclear power stations? Will a major commitment to nuclear power make economic sense when seen against the full range of alternatives? By that I don't simply mean coal and oil and indeed major renewable sources of energy which Mike Gammon's chart pointed to. But I also embrace such possibilities as a systematic programme of energy conservation, local combined heat and power on a much broader scale and, in the longer run, the development of solar technology.

Now the CEGB will say - rightly perhaps - that this isn't their remit. But I suggest that it is consideration of these sorts of alternatives that will increasingly shape public attitudes when new nuclear proposals are brought forward.

The first point on economics is simply that despite CEGB's assertions, despite the charts which have been put up today and despite the Government's endorsement, effectively, of the CEGB's analysis on this question, it is increasingly doubtful that nuclear stations in every case are necessary or economic in the longer term. There are reasonable doubts simply on the basis of CEGB's past performance in relation to the costs of nuclear power and in the light of the Government's and CEGB's assumptions about the inevitable growth of electricity demand in the years principally after the year 2000. Just look at CEGB's past performance on costs. The Select Committee on Energy's recent report made some truly astonishing criticisms of the historically false presentation of nuclear costs by the CEGB. I quote: "The historic cost method used by the Generating Board to justify past investments distorts the effect of inflation on capital cost, rendering the resultant figures highly misleading as a guide to past investment decisions and entirely useless for equating future ones". Perhaps Mr. Gammon will comment on this? You need to look at the figures that you saw on the chart he put up a few minutes ago in the light of that criticism. It is a criticism which was repeated, also this year, in an important report by the Monopolies Commission.

Add to this the colossal historical cost overruns which nuclear power has experienced in this country - the AGR programme, characterised by Professor David Henderson of London University as one of the three biggest civil investment disasters in recorded history and, in my own experience, staggering cost escalations in schemes like the Dinorwic Pump Storage scheme which isn't even a nuclear scheme but where comparable dynamics are at work. Even on this basis, there are likely to be increasing questions asked about the economic basis of CEGB's investment plans for nuclear.

The official long range picture of future electricity needs again gives one a growing basis for scepticism which, I suggest, will find its way into controversies about new investments in nuclear power. The record shows a staggering and repeated over-provision by the Generating Board of electricity generating capacity. In the view of some experts, this has been greatly exacerbated by the

Board's increasing commitment to claimed economies of scale, since these mean the reserve margin entailed by such large generating units has to be ever greater. At present CEGB needs a 28% safety margin over and above its generating capacity for peak demands. The difficulties for CEGB have been fed equally by false assumptions about the way electricity prices would behave. As they go up, demand comes down and predicted growth in demand does not materialise.

Coupled to this, on the forecasting side, there is growing awareness, increasingly reflected in some official quarters, of the huge potential for more efficient use of the energy that we already produce, which is being foregone. Mike Gammon's rather casual dismissal of the significance of greater energy efficiencies for energy policy over the long run should not be accepted. A recent study backed by the Social Science Research Council by Gerald Leach of the independent International Institute for Environment and Development, which was put in as evidence to the Select Committee on Energy two or three months ago, has shown that, on capital costs alone, a large programme of insulation in housing is likely to be cheaper than almost any supply technology and may be 4 - 10 times more cost-effective than electricity. This is crucial, of course, because a systematic programme of domestic insulation would eat particularly into peak electricity demands and the anticipated future heating demands on which a nuclear programme is increasingly predicated.

Similarly, the Parliamentary Select Committee on Energy in its report earlier this year recorded dismay that seven years after the oil crisis, the Government still lacked any clear means of determining whether investing £1,300 million in a single nuclear station would be as cost-effective as spending an equivalent sum in energy conservation. In its response to this analysis by the Select Committee, the Government has simply tried to sweep the issue under the carpet.

In the last few days we have seen the publication of the report of the Commission on Energy and the Environment, on

"Coal and the Environment". It is the Commission's dying fall. The Commission is now to 'fall into abeyance', in the Environment Secretary's words. But this official body has recommended a major study evaluating the risks inherent in a supply oriented energy policy - that is to say, a policy which places very heavy emphasis on increasing supplies, in which the CEGB's role is so important - compared with a policy emphasising much heavier investment in efficiency of energy use.

May I simply conclude this point by saying that there is a well-informed and growing anxiety that investment in supply on the colossal scale implied by CEGB's nuclear preferences is increasingly at the expense - and indeed very misguidedly at the expense - of more efficient ways of satisfying energy needs. One need only point to the remarkable contrast between the £1500 million spent by the energy supply industries as a whole in 1979 with the paltry tens of millions the Government is spending this year on energy conservation.

The relevance of all this for the public acceptability of nuclear power is that it is new nuclear proposals which will bear the brunt of public concern relating to these issues. I suggest that there is a deep and increasingly sophisticated scepticism about the unsatisfactory policy framework from within which nuclear proposals will spring. Hence there will be growing pressure in that sphere. I might add in parenthesis that, judging from what Shirley Williams said at the Social Democrats' Conference (October 7, 1981) it would be surprising if the Social Democrats' energy policy didn't begin to reflect some of these new concerns.

Well, there we have some of the long run economic factors bearing on nuclear power. I can deal more briefly with the other points my paper mentions. The economic question interacts with the question of nuclear safety. There are, of course, considerable anxieties in many people's minds about pressurised water reactor safety and fast breeder reactor safety in the longer run. These concerns relate to the scale of a possible accident and indeed to the whole matter of weapons proliferation. I'm not going to explore these factors today.

The more significant matter, I think, for an audience like yourselves is that there is a crucial relationship between nuclear safety and capital cost; the more safety you build into a nuclear station, it appears, the higher the capital cost. We have heard rumours in recent months about modifications to CEGB's safety requirements vis-a-vis the PWR on cost grounds, amongst others. Perhaps Mr. Gammon would like to comment? American studies which found their way before the Select Committee on Energy last year, show that the added cost of new safety provisions once things go wrong with nuclear stations - for example, as at Three Mile Island - add to capital cost burdens very substantially. In such cases, you have to go back and modify all the other plants that were constructed on the same basis that gave rise to the fault in the individual reactor in question. These studies show that, in the States, nuclear power is becoming and will increasingly become increasingly uncompetitive even with coal-fired stations. I don't say that this applies identically in Britain, because obviously the coal cost situation is different. Nevertheless, it is a pointer to a dynamic that is about to affect Britain once we adopt an American technology, the pressurised water reactor. For Britain will then become subject to the same pressures. Incidents that take place in Japan, in France, in the States affecting pressurised water reactors will directly impinge on CEGB and on nuclear costs. The views of these American experts present a sharp contrast to the CEGB's stated assumption that the capital cost of future nuclear investment, say the PWR, can be regarded as relatively stable. As I say, these American studies suggest that exactly the opposite is likely to be the case, for reasons of additional capital cost, related to safety.

The third factor of concern that I mention in my paper, which is likely to continue to trouble a great many people, is the question of waste disposal - disposal of the toxic nuclear residues remaining after electricity generation has taken place. I should underline the fact that there are still no signs of a solution, a politically acceptable solution, to the disposal of the most toxic nuclear wastes, the high level wastes. The Government's Advisory Committee has said just this year that (probably because of the political difficulties of finding sites) the answer is simply to keep such wastes above ground at places like Windscale, for the next fifty years, and that we can postpone decisions on ultimate disposal. This contrasts with the recommendation of the Royal Commission on Environmental Pollution -probably the most august body in Britain to have looked independently at nuclear power over the past 10 or 15 years - that there should be no commitment to major nuclear expansion until the problem of waste disposal had been conclusively solved. We now have the Government's official Advisory Committee saying we don't need to solve the problem for another 50 years. I am not questioning here the merits of what any of these people are saying. But I just put it to you that such judgements will give rise to increasing public unease which will find its way into discussions and debates about nuclear power.

What is more, there is now (and recent statements have shown this) an urgent problem about intermediate level wastes - less toxic, but still pretty unpleasant. The Atomic Energy Authority is going to have to find sites for dumping these wastes somewhere in the countryside increasingly over the next few years, as nuclear expansion takes place. When I think, from my own organisation's point of view, of the difficulties that local authorities experience even in designating sites for gipsy caravans, I think it is reasonable to assume that the prospects of finding sites for that sort of stuff are slim.

This leads to the fourth item mentioned in my paper - the question of local environmental factors and the bearing these will have on discussions about new nuclear proposals. All new nuclear proposals will require sites, most of them rural sites. But the sites that are now being sought by CEGB and others are becoming more and more controversial, because there are more and more conflicting interests involved. We live in a very, very crowded island and, from where I sit in the CPRE, I can assure you there are very many conflicting interests that will be interested in the sites the CEGB is interested in. As the Board brings forward proposals in beautiful rural areas in Cornwall, Dorset, Northumberland, and so on, it will dislodge a hornets' nest of protest. The passive resistance of Luxulyan in Cornwall, to which Mike Gammon referred, which has forced the Board into the courts in the last few weeks in an attempt to dislodge objectors to their site investigations, gives a hint of the feelings such proposals will arouse. That is simply a political fact that will have to be increasingly recognised.

Well, those are four concerns which, to my mind, will increasingly interact in the public response to new nuclear power proposals. They are not catered for in the charts that Mike Gammon has shown you. Official consultations are one thing; but I have tried to tell you about the public that is not covered by those institutions.

May I turn now, as I do in my paper, to just two further, deeper factors which will also help shape public responses The first of these is that the electricity supply and nuclear industries, as well as the Department of Energy, see the development of thermal nuclear power as the precursor to a widespread introduction of the fast breeder reactor. I accept Mike Gammon's qualifications to this - that the CEGB has no formal commitment to the fast breeder reactor or plutonium fuel cycle. However, the CEGB is most anxious that the fast reactor should be developed.

My suggestion is that the investment of truly colossal sums of public money, both in the past and in the future, in the fast reactor, will increasingly predispose the Government to favour its introduction. The Chairman of the Atomic Energy Authority has said recently that, 'Without fast reactors, nuclear power can make a useful but comparatively short-lived contribution to the world's energy supply. But, with the fast reactor, nuclear power becomes the most important world energy source of the future'. Now, there are many people who would simply not accept that judgement. But the judgement, I suggest, will be an influential one. Certainly it will be influential on those people who dislike the prospect of the plutonium fuel cycle and who will see current investment in the thermal reactor cycle as, so to speak, a stalking-horse for the fast reactor.

I mentioned in my paper that the plutonium fuel cycle has serious civil liberties implications. This is an issue which there is no time to go into here. Suffice it to say that, on postulates adopted by a recent international review of future nuclear development, the INFLE Review, the quantities of plutonium, the raw material for nuclear weapons, that could be floating around if there were a major industrial world commitment to the fast reactor, are truly horrific. The figures were quoted at a conference in Paris a week or so ago: 10,000 tons a year of separated plutonium worldwide by 2025. The civil liberties' implication for Britain would be that, with hundreds of tons of plutonium being used and made in a domestic civil nuclear programme, Governments would have no alternative but to adopt the most stringent and wide-reaching security measures to prevent theft or diversion of these materials. These security measures in turn would entail serious damage to civil liberties. That factor may seem to you a very remote consideration and hardly relevant to the CEGB's need to provide electricity next year. It is a factor nevertheless that will shape public attitudes. It is a genuine concern; it was a concern which was endorsed even by the Royal Commission on Environmental Pollution in 1976. Such anxieties are not going to go away as new thermal nuclear developments are brought forward; they are likely to intensify.

This leads me to my final point of substance. It relates to the nature of the nuclear industry itself and the difficulties this creates for, for want of a better word, public participation. Nuclear development has a certain industrial and institutional logic; it is a very advanced technology; it is a very capital-intensive technology; it is a technology whose implementation involves very long lead times - very long lead times sometimes, as I think the CEGB would agree: 10, 11, 12 years for a power station, from conception to actually delivering the goods.

Nuclear power, therefore, needs certainty of long range planning. This implies that individual nuclear developments will be embedded in larger long-term programmes and plans. The industry and the major industrial suppliers to the industry claim, I think probably rightly, that only a steady ordering programme of nuclear power stations could conceivably make economic sense. It is not worth the suppliers' while to stay in the game without the guarantee of a steady ordering programme. The industry now has the Government's support for this view. That was why the rather opaque commitment to 15,000 megawatts over the next 10 years was made by the Government in December 1979. The Secretary of State wanted to reassure the industry that it would have a steady ordering programme to some extent.

Such reassurance conflicts fundamentally with public expectations of genuinely open-ended discussion of nuclear decisions - of the possibility of unravelling some of these very controversial issues which I have been elaborating over the past few minutes. There is growing concern about these issues. And there will be considerable resentment if inquiries do prove not to be genuinely open.

It seems to me likely that the Government will feel itself forced to constrain the scope of inquiries. There are two irreconcilable positions - the public's wish to go into issues which appear to be unresolved and uncertain. And the industry's need for certainty and getting on with the job. Very understandable, both sets of priorities, I'm sure you will agree. And political facts, both of them. The dilemma will tend to encourage the Government to abbreviate public inquiries, in the industry's favour. After we have had the big Sizewell Inquiry, there will be an inevitable wish to cut back the scope of further nuclear power inquiries.

However, for the reasons I have given, I do not think that abbreviated public inquiries of the sort that a significant nuclear programme would require will be able to contain the tensions that will arise. And I think that the Luxulyan incident, again, shows the sort of thing we may be in for. One need only look at the incidents that occurred in very comparable circumstances, vis-a-vis the motorway programme in the mid-1970s, with John Tyme and quite widespread civil disobedience, to see what could be set in motion. It is worth mentioning, as a recent study by William Walker and Mans Lonnroth of the Royal Institute for International Affairs indicated, that the most successful nuclear programmes in the world have been those of France and Russia. And the common characteristic of these two countries - of their energy systems particularly - which have made effective implementation of nuclear programmes possible, according to this study, are the existence of highly centralised energy bureaucracies with very, very few impediments, and certainly an absolute minimum of public participation or consultation. It seems to me that is a highly significant fact and one which ought to give all of us in Britain considerable cause for concern.

Chairman, that is my prognosis as a relatively detached analyst. I see acute difficulties ahead for nuclear developments in the United Kingdom. I think that very wide concerns about energy policy and public policy generally will focus on particular CEGB proposals. And poor old CEGB, I think, is going to be in the front line. It follows, in my view, that it would be prudent for government to begin to look with much greater urgency at other long term directions into which energy policy might move, which will not present these acute problems of public acceptability in an open society.

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PRESENT ACHIEVEMENTS AND FUTURE REQUIREMENTS

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SUMMARY

This paper represents a view from within the Society which examines the basis of present achievements in air pollution control, how pollution is perceived today and identifies shortfalls in specific areas e.g. policy management and the framework for control. The second part of the paper is devoted to future requirements in several areas of pollution control, which currently are of concern and interest to the Society.

INTRODUCTION

As a representative of the N.W. Division on the Council of the Society and an Officer of the Warrington Borough Council actively engaged in pollution control measures, I consider it a great privilege to have been invited to present this paper to the 50th Clean Air Conference here in Torquay.

I am extremely grateful to the Officers of the Society who have assisted me with so much material that has been utilised to prepare this paper, and my own Local Authority which has long supported the National Society for Clean Air and allowed me the time to become so involved with Society activities.

The views expressed in this paper are of course my own and do not necessarily represent the views of either the Society or the Warrington Borough Council.

THE BASIS OF PRESENT ACHIEVEMENTS

As the audio-visual dramatically emphasised, the nation has done well in freeing most - although by no means all - of its citizens from the twin scourges of dark smoke and hazardous concentrations of sulphur dioxide. This was not achieved without considerable effort and cost; it was a complex exercise in which outside factors were also important. The trigger was public opinion formed by the knowledge that the standards and practices of the past had been overtaken by improved technology. As national wealth increased and the standard of living improved, clean air was recognised to be not only affordable but essential to the wellbeing of the nation. The principal outside factors were the wide availability of clean fuels such as natural gas, and more efficient production technology. Latterly, reductions in pollution have resulted from the world recession which led to the decline in heavy industrial output.

While the simplest measure of the attainment of clean ai is the reduction of visible smoke, and the striking appearance of newly cleaned buildings, it should not be forgotten that 25 years of smoke control were preceded b almost a century of industrial emissions' control under the evolving Alkali and local Acts. If the initial trigger then was the objection of vested interests to the despoilation of Lancashire by acidic emissions, it is equally true that public perception of the benefits of such emissions' control led to the rewriting of the legislation and the subsequent additions to the list of scheduled processes.

The history of the National Society for Clean Air and it antecedents mirrors the changes in social attitudes towards air pollution. The existence of such environmental interest groups enhanced public perception of the problems, in this case making people more aware of the sensation of being polluted by the air they breathe. The degree of awareness depends on how much the population is protected from air pollution, either by natural metabolism or by technical controls, but also on what the requirements or standards of the public are and on the variation in levels of pollution experienced.

HOW POLLUTION IS PERCEIVED TODAY

In the early 1970s, when there was a resurgence of interest in the environment, public perception of a whole range of pollution problems was at its height. People identified very closely with environmental issues and resources of air, water and land were seen as collective goods (or evils, if polluted). While the policy that the polluter should pay to clean up his own effluent was widely accepted, people as consumers were more prepared to pay their share of the price of clearing the air and securing a clean environment.

Today, pollution is still a matter of general concern and pollution control has become good politics locally, nationally and internationally, and relatively big business. It sells newspapers and electrostatic precipitators, and funds university departments. Campaigning groups and investigative reporting ensure that many potential threats are accorded wide public discussion. However, public awareness of a particular hazard does not necessarily mean that its nature and extent is widely understood. In most circumstances the citizen is content to leave that to the expert; it is when experts disagree, or appear biased or indifferent, that public faith in their infallibility is shaken.

There is, however, a negative side to the public perception of pollution problems. Perhaps some of the issues have been over-exposed, and certainly familiarity with long standing problems which appear not to pose an immediate threat can lead to complacency, or more often a feeling that nothing can be done. Successive governments and their advisers seem to have understood this well; while they may deal swiftly with certain sensitive issues, it took seven years for a response to be made to the wide ranging 5th Report of the Royal Commission on Environmental Pollution, and statutory bodies such as the Clean Air Council and the Noise Advisory Council have been discarded with barely a whimper. The politics of clean air is constrained by economic considerations and without sustained public pressure, Government is unlikely to take an innovatory and developing stance on environmental protection, or pursue clean air to the limits of current technology.

Nevertheless, many pollutants from many different sources have been the subject of control in urban and industrial locations over the last 120 years. Some measures have been more successful than others, for a variety of reasons. The following section examines some of the reasons for the shortfall in objectives, whether for the protection of health and the natural systems upon which we depend for our existence, or for the protection of amenity.

SHORTFALLS IN SPECIFIC AREAS

Policy

The traditional processes of policy making are often slow, particularly in the absence of any sense of urgency. In the past it was possible to excuse the slowness with which air pollution legislation was introduced, on the grounds that it was in accord with the values prevailing at the time. While much has been achieved over recent decades to improve the air we breathe, and while much knowledge and experience have been accumulated in the meantime, one vital lesson does not seem to have been learned. The control of pollution still lacks overall cohesion. We do not have a national environmental strategy which would provide a framework for progressive policies on specific issues. Government continues to react to events, rather than anticipate them, so that problems are inevitably dealt with piecemeal.

It is more difficult and costly to make significant improvements once gross pollution problems have been reduced to certain levels. In the present financial climate Government would argue that it is as forward looking as informed opinion and prudent concern for tax payers' pockets allows. However, many pollutants present in the environment pose a potential threat to health, or may have long term effects on the environment. It is important that society as a whole continues to press for improvements in air pollution control and the provision of adequate resources in terms of cash and manpower so that effective monitoring and enforcement can be carried out. It is ironic that the principal thrust for improvement today comes from Brussels, as the succession of Community Directives and action programmes on the environment attest.

Membership of the EEC has drawn the United Kingdom into a new approach to air pollution control, involving the nation in a commitment to air quality standards. The then Chief Alkali Inspector, in his report for 1981, commented that Britain's traditional Best Practicable Means (BPM) approach is entirely compatible with the air quality concept. The degree of compatibility will, however, depend upon what standards are set in a particular Directive. The UK has its input to all stages of discussion while Directives are being formulated, as do other member states of the EEC. Yet this could change if a current Commission proposal for setting emission standards is accepted. As it stands, the proposal is that such limits should be set by a qualified majority of the Council of Ministers, rather than unanimously, as at present.

Thus, the UK will be led down yet another control path by the Commission, the setting of statutory emission limits, and possibly obliged to implement limits with which the UK government and/or the UK experts do not agree. The UK has been accused of dragging its feet during negotiations on environmental issues within the EEC. This has certainly been true, but on the other hand Britain's record of implementing the Directives once they are passed is very good. It could be argued that attempting to set standards that are achievable in technical and economic terms is part of a responsible approach to air pollution and other environmental controls. But the fact remains that Britain has rarely taken the initiative within the EEC, and has certainly lacked the advantage of the pacemaker. Britain's volte face on lead illustrates this. When the lead in petrol directive was first mooted, the then British Government successfully delayed its introduction. Thus, the UK record on the issue is scarcely the ideal basis on which to urge the rest of the Community to eliminate the lower limit in the Directive so that lead free petrol can be introduced in Europe.

Currently, the Department of the Environment is attempting to justify Britain's position on the long range transport of air pollution, within the UN Economic Commission for

Europe (ECE) Convention Executive Body and in EEC negotiations. At the same time, DOE is undertaking (as promised in the Government's delayed response to the 5th Royal Commission on Environmental Pollution (RCEP) report) a review of air pollution legislation. The two processes would seem to be interdependent and it must be difficult for British representatives to explain Government's position on a major air pollution issue before the overall policy for air pollution control has been finalised. Nevertheless, the fact that such a major review is being undertaken, however slowly, is a hopeful sign that attitudes towards policy are changing within Central Government.

Management

The natural concomitant to a change of attidue towards policy is the development of a more concerted management approach to dealing with pollution problems, whatever the form in which they arise. In recognising this, the Royal Commission in 1976 argued cogently for the adoption of an "integrated approach". Government responded by saying that while the logic of this was unassailable, it was not easy to assess the benefits that might accrue from its application. Thus, they did not see any need for substantial changes in the existing organisational arrangements for pollution control - it would seem that they are content with the basis of management. Yet, looking at the tangle of Directorates or equivalent groups within the Department of the Environment, the Health and Safety Executive, the Departments of Energy, Trade, Transport, Agriculture and Defence - not forgetting the Welsh Office, the Scottish Office and the Department of the Environment for Northern Ireland - it is difficult to imagine how these can all unite in the absence of a central management strategy. In the event, they do not - as successive reports from an ever lengthening list of members of the Royal Commission on Environmental Pollution point out.

While rejecting the need for any substantial changes in the organisation of pollution control, the Government recognised that in appropriate cases closer liaison between the different control authorities was essential, to the extent that effective liaison and agreed procedures will enable the existing enforcement agencies to continue to operate autonomously. Whilst there may be no quarrel with the Government's rejection of Her Majesty's Pollution Inspectorate (HMPI), experience suggests that simple liaison is not enough. The NSCA put forward (as long ago as 1977) the view that to draw everything together will require some sort of National Joint Consultative organisation which would represent all the professions involved. Such a body would not require any executive powers, but could provide a forum within which agreed strategems for all aspects of pollution control could be formulated, interpreted and where necessary reinforced with specific advice.

It could be the arbiter on the division of responsibility between central and local control, and on the principles of control. Equally, it could be concerned with the British input to the Commission of the European Communities, the setting of Best Practicable Means (BPM), and consent procedures. It could assess the needs and arrangements for research and planning. In the same way this suggested central advisory body could provide the links with those agencies having statutory responsibility for control of radioactive discharges - a particularly emotive and sensitive area of debate.

Framework for Control

While generally favouring the policy of best practicable means (BPM) the Society has identified areas in which the application of BPM could be supported by more stringent operation of the polluter pays principle and by greater co-operation between the local authorities and HM Industrial Air Pollution Inspectorate, who between them control emissions to atmosphere.

As practised in the UK, the polluter pays principle is the limiting economic element of BPM. In times of recession, or economic difficulty for a particular industry, this element is applied flexibly by, for example, adjusting the timing of the imposition of controls. In recent years, some old industrial plant has been allowed to operate to the end of its useful life in order to protect jobs (a laudible aim) while not being required to implement BPM on the grounds that it would be excessively costly. The result is that in specific areas, the cleanliness of the atmosphere may lag behind the achievable and hence the desirable. The NSCA therefore considers that the control approach should be modified to include as necessary the award of public subsidies and other elements of the polluter pays principle at present not practised in the United Kingdom.

Such subsidies are particularly important when major changes in energy use are being implemented (e.g. conversion from oil/gas firing to coal firing). A specific example of an industry where grants or subsidies or this type should be supplied is the Phurnacite Plant at Abercwmboi, about which the Society's Welsh Division in particular has campaigned vigorously in recent years. The plant makes smokeless fuel for the benefit of the nation as a whole, but in the process creates unacceptable levels of local pollution. In order to protect the environment, jobs and supplies of smokeless fuels, a substantial sum of money of some sort is needed to modernise the plant and prevent the present gross emission levels.

The Government decided that HM Industrial Pollution Inspectorate should stay within the Health and Safety Executive and not be returned to the Department of the Environment as recommended by the NSCA and the Royal Commission on Environmental Pollution. The arrangement appears to be administratively convenient at the present time although there may still be some faint hope of shifting Government opinion on the matter in the future.

In August 1983 the control of air pollution from 300 factories passed from local authority to Industrial Air Pollution Inspectorate control, as a result of new regulations under the Health and Safety at Work Act.

The regulations deschedule a number of processes no longer used in the UK, and hand over to the Inspectorate the control of asbestos works and several types of lead and di-isocyanates works. A number of materials have also been newly scheduled as "noxious or offensive substances", including asbestos, metal carbonyls, vinyl chloride, ethylene and the higher clefins. Section 78 (2) of the Control of Pollution Act 1974 is repealed and it is expected that local authorities will take responsibility for monitoring cable burning in non-scheduled premises.

One devolution of responsibility from central to local authority is promised in the Government response to the Commission on Energy and the Environment report on "Coal and the Environment". The Government endorsed the proposal that planning authority over opencast coal mining development should be transferred from the Energy Secretary to local councils. There is a possibility that further powers may be given to local authorities, as a result of the review of air pollution control policy which is underway. The greatest need is for local authorities to have wider prior approval powers (at present these are confined to a few specific matters such as the control of chimney height). Local councils would also need powers to enforce BPM requirements on non-combustion processes if some of the works currently controlled by IAPI are to be descheduled and passed over to local authority control. Increased prior approval powers for local authorities would certainly be required should the proposed EC Directive on combating air pollution from industrial plant become mandatory; the list of processes to be subject to prior authorisation in this way includes several classes of premises currently under local authority supervision in the UK, e.g. food and waste disposal industries.

The question of planning powers enjoyed by local authorities gives rise to problems in some areas where, following government advice, the highest priority is given to the attraction of investment and the creation of employment. This is not necessarily compatible with securing or even maintaining lower levels of air pollution. The NSCA is naturally concerned to ensure that planning authorities keep in mind the need to preserve, and where possible improve, levels of air quality which have been so hard won during the last two decades.

FUTURE REQUIREMENTS

1. Smoke

(a) Domestic Smoke Control

In the UK towns and cities which were once so polluted, smoking chimneys (either industrial or domestic) now generally stand out and can be readily identified. Even so, in some districts smoke control programmes have never been implemented, whilst in others approved programmes have slowed down or been suspended. The EC Directive on health protection standards for smoke and SO_2 sets limit values for these pollutants and it is evident from National Survey data that the limits are likely to be exceeded in parts of the UK. Thus, some areas will need to progress their smoke control programmes more positively, and other areas which have never considered smoke control necessary will need to introduce programmes in the future.

The Local Government Planning and Land Act of 1980 allows Local Authorities to establish smoke control programmes without the prior consent of the Department of the Environment. The only requirement is that the Department be notified in advance of likely financial expenditure, in order that it can approve its element of the overall cost. The cost of smoke control programmes does of course count against the capital expenditure allocation to each local authority.

The eligible expense limits for conversion of appliances present funding difficulties in some areas, particularly those with coal mining communities. The Department of the Environment have recognised that the costs of smoke control in such areas are likely to be greater; at this stage, the Department are not prepared to make available a larger grant in order to help the local authorities wih with their smoke control programme.

In districts which have completed smoke control and are still approaching the EC limits, it may be necessary to introduce regulations under Section 76 of the Control of Pollution Act, 1974, to limit the sulphur content of fuel. These Regulations have been previously utilised in 1976 (viz. Motor Fuel & Fuel Oil (Sulphur Content of Gas Oils) Regulations 1976) to limit the sulphur content of Derv and heating oils to comply with an earlier E.C. Directive.

A further increasing problem in some areas is the reversion to illegal burning of bituminous coal in smoke control areas. There are several reasons for this, and the underlying causes are different in various parts of the UK. One of the problems that the Society has identified, during a comprehensive survey last year, is ignorance of the law; another is the apparent attractiveness of coal on cost grounds. Local authority manpower to police smoke control areas is also in short supply. When smoke control programmes are introduced, the manpower requirements are fairly intensive. Once the programme is completed, Environmental Health Departments move on to other areas of pollution control which absorb staff time and skills. Having to revert to checking up on domestic smoke emission is difficult, and could set back the achievement of other progressive pollution control programmes.

The NSCA believes that it is essential to oppose illegal coal burning strenuously from the outset, and that, if necessary, new legislation or amendments to the existing law should be introduced to help local authorities combat the problem.

(b) Smoke from Road Vehicles

The EC Directive on smoke and SO_2 has been interpreted officially to refer to emissions from stationary, rather than mobile, sources. However, smoke from road vehicles is making an increasing contribution to concentrations in heavilly trafficked urban areas, and it is possible that alongside major roads levels of smoke may be in excess of the permitted limits. Because the former National Survey network was specifically organised to exclude such localised sources, there are at present inadequate data on kerbside concentrations, although it is expected that in the future more attention will be given by many local authorities to the monitoring of roadside pollution levels, providing that resources are available.

Legislation exists which limits the output of smoke from new vehicles (diesel engines). The NSCA has long been outspoken on the need for tighter controls, and considers the present standard inadequate. It has called for stricter smoke emission acceptance testing of new vehicles (to reduce from the outset the potential for smoke emission) and for more checks on emissions from vehicles in use on the road.

(c) Smoke from Stubble Burning

The quantity of straw and stubble burnt after the cereal harvest has increased in recent years as grain production has risen and the demand for straw in the main cereal growing areas has fallen. While for the farmer the post-harvest burn is a quick and inexpensive way of clearing the ground and dealing with surplus straw, complaints about smuts and smoke, hazards to road traffic and damage to hedgerows are increasing. However, little work has been done to establish just what effect the emissions have on air quality. It is not known whether they may amount to a health hazard (i.e. if in breach of the EC Directive on Smoke and SO_2) or how far the smoke and char fallout from a burn can spread.

The NSCA co-ordinated a programme of monitoring during the 1983 harvest season (which will be expanded in following years) to try and establish the nature and extent of the problem, and provide evidence for future action. The three-pronged exercise, carried out with the co-operation of local authorities, the CEGB and Warren Spring Laboratory, covered: analysis of historical data on smoke and SO_2 emissions to show the impact of straw and stubble burning over the years; studies of visibility reduction during the harvest season; measurements of smoke pollution and smut deposition in selected areas during the six weeks from the beginning of August. The results of the present monitoring programme will be debated and published in the future. Straw and stubble burning has been a recurring theme at conferences and meetings of the Society, which has resolved to secure more effective control of the practice. Proposals put forward include giving increased powers to local authorities for prior approval and more stringent supervision of burns, and the introduction of a ban within five years.

2. Acid Rain

Research and discussions on the cause and effects of the long-range transport of air pollution have been underway for the past decade. Intensive effort has been devoted to monitoring the transboundary flux of emissions, and to measures which would reduce the problem either at source or point of impact. Until a few years ago, the effects of acid rain were considered to be confined to specific areas in Scandinavia, the Northern United States and Canada. More recently, researchers have suggested that acid deposition may be affecting parts of the UK, notably Scotland, North West England and Wales.

As a result of international concern, acid rain has become the focus of political discussion and negotiations, within the framework of the United Nations Economic Commission for Europe (UN ECE) Convention, and in the EEC. In March this year the Prime Minister, at a meeting of the Council of Ministers of European Communities, signed a statement to the effect that "the damage done to the forestry environment by acid rain makes effective joint action urgently necessary". The statement then went on to invite the Council to give "rapid and positive attention" to the proposals announced by the Commission of the European

Communities for action, both within the Community and in the context of the Convention on Long-range Transboudnary Air Pollution. The proposed Community action takes the form of a 'framework' draft directive, empowering Council to set emission limits on a number of pollutants from a wide range of industrial processes (already referred to). Desulphurisation of fuels or flue gases is one suggested means of reducing the emissions which contribute to acid rain, but these measures are relatively expensive. Looking at the electricity generating industry in the UK, which contributes about half of total SO_2 emissions to atmosphere, it has been estimated that desulphurisation measures could add about 5% to the price of electricity, with corresponding increases in the price of other products.

A further method currently being researched in the United States is known as the NOXSO process. This utilises a grandular sorbent to capture both SO_2 and NO_x in sodium oxide on an Alumina substrate. Once it is saturated with SO_2 and NO_x the sorbent can be regenerated by treatment with hydrogen sulphide. This produces elemented sulphur and nitrogen. No doubt we will hear further from the States on development of this new process.

The problem of acid rain is a function of many emissions in many countries. Sulphur dioxide, nitrogen oxides, hydrocarbons and photochemically produced oxidants are all thought to be involved. High, medium and low level sources all contribute; thus, stricter controls may be directed at motor vehicles as well as the large industrial emitters. The solution has to be found in the broad context achievable under the terms of the UN ECE Convention, which requires countries to limit and so far as possible gradually reduce and prevent air pollution, including long range transboundary pollution. The NSCA has issued its recommendations on these lines and suggests that the UK and other signatories to the Convention should agree to meet a target percentage reduction in emissions by a specified date, but that the strategy for achieving this should be the responsibility of each individual country.

3. Lead

Few pollutants have been as widely debated as lead. In recent years, the controversy surrounding the contribution of lead in air to body-lead levels, and the significance of lead in petrol as a source of lead in the environment, has been widely reported and has been the subject of much scientific study.

A concentrated campaign over the past 18 months or so, led by CLEAR and other environmental groups, including the National Society for Clean Air, culminated in a recommendation in the 9th Report of the Royal Commission on Environmental Pollution that lead should be eliminated from petrol as soon as possible. The Government accepted this recommendation the day it was made, and set a target date of 1990 or earlier for the introduction of lead-free petrol. The Government considered, however, that this should be achieved in harmony with other members of the European Community, by eliminating the lower limit in the EC Directive governing the lead content of petrol. Discussions on ways and means are now underway with the oil industry, motor vehicle manufacturers and our partners in the European Community.

More recently (July 1983) the West German government announced that it will seek the introduction of lead-free petrol by 1986 at the latest, and will act unilaterally if the EEC cannot agree to that date. The Federal Republic of Germany is anxious to introduce lead-free petrol in order that catalytic converters can be fitted to motor vehicles, to control emissions of nitrogen oxides and hydrocarbons to atmosphere. The concern is that these emissions participate in processes of photochemical oxidation, leading to raised ozone levels which are believed to be responsible for forestry damage in areas of the Federal Republic of Germany. Austria and Switzerland have since followed suit with similar announcements.

The Royal Commission's report on Lead in the Environment made 29 specific recommendations on reducing levels of lead in the environment, and securing tighter control over all sources. The NSCA, in its evidence to the Royal Commission, made clear its concern for a reduction in all forms of environmental lead, and welcomes the commitment by the Government, in their response to the 9th report, to pursue this broader objective.

Local authorities will obviously play a major part in securing environmental lead reductions and will have to be vigilant in monitoring all sources of lead pollution to ensure that emissions are either eliminated or reduced to the lowest practicable levels, consistent with the health hazard presented.

4. Pollution from Road Vehicles

Emissions of smoke from road vehicles have already been mentioned, but, as noted above, there are moves afoot in the Federal Republic of Germany (FRG) and several other European countries, to secure tighter control over other emissions (NO_x, CO and hydrocarbons) from road vehicles. Trends in the observed concentrations of these pollutants, where monitored in the UK, generally suggest that in most areas concentrations are reasonably static, or falling. However, they are still dominated by isolated periods of high pollution. Urban concentrations of carbon monoxide arise predominantly from motor vehicles, which also make a strong contribution to kerbside nitric oxide concentrations. Nitrogen dioxide levels are generally only slightly influenced by vehicles in the street, although the origin of general urban levels is not clear (Department of the Environment. Digest of Environmental Pollution and Water Statistics, 1982). Emissions from new vehicles have been progressively controlled under a series of regulations emanating from the United Nations Economic Commission for Europe, framed in EEC Directives and enacted in the legislation of member states. Catalytic converters would allow vehicles to meet even stricter exhaust emissions standards; nevertheless, catalyst control systems are not the only solution and considerable research is being directed to improve engine design to reduce emissions at source.

Paradoxically, clearing the air of smoke and thus increasing visibility and hours of sunshine, has helped the formation of higher ozone levels, occurring as a result of photochemical reactions involving hydrocarbons and oxides of nitrogen, associated with periods of hot sunny weather. The NSCA is obviously concerned that the situation in the UK should not deteriorate and the need for stricter controls on road vehicle emissions must be judged in relation to monitored roadside concentrations of NO_x, CO and HCs and atmospheric ozone levels.
roadside concentrations of NO_x, CO and HCs and atmospheric ozone levels.

5. Monitoring Needs

The Coal Smoke Abatement Society, forerunner of the NSCA, instigated in 1910 the first attempt to carry out experiments to estimate the amount of matter deposited from London's atmosphere. An extensive air pollution monitoring programme was later established, culminating in 1961 in the National Survey of Air Pollution. This Survey has been extremely valuable in recording progress in reducing concentrations of smoke and sulphur dioxide. It was the most comprehensive of its kind ever established throughout the world, and provided a continuity of data over a long period of time and in terms of spatial coverage. In 1981, however, the design and operation of the National Survey was re-examined in the light of the EC directive on smoke and SO_2, central and local government resources, and general data requirements. It was concluded that a long-term network of some 150 sites (as against some 1150 previous sites) would adequately meet national requirements in terms of trends and geographical coverage, and could be supplemented by ad hoc surveys designed to meet more specific (national) needs (e.g. in relation to those areas where pollution levels are likely to approach or exceed the limit values in the EC Directive.

However, the new survey cannot meet all local needs. Many local authorities have designed and operated specific surveys for other pollutants such as lead, other heavy metals and oxides of nitrogen. To a large extent, the need for such surveys has to be determined locally, although Government may give advice on the desirability of monitoring (e.g. lead levels) at local level, to supplement centrally co-ordinated surveys. Unfortunately, this advice is not supplemented by any specific grants of money to carry out the surveys. The larger, urban Councils are richer in terms of manpower and monitoring equipment than many smaller local authorities, but even their resources will not stretch indefinitely. In order to make the best use of resources, local authorities are collaborating in several areas (often within existing area air pollution management groups) to finance and operate local surveys. Some groups have fitted out mobile monitoring units and created a flexible, sophisticated monitoring facility. Analysis is also a problem; again pooling resources is helpful. County Council computers and laboratories can be used to process samples and data.

A great deal of thought will need to be given in the future to the determination of monitoring needs at local level and the best ways of using existing resources and disseminating the information collected to the maximum benefit.

6. Asbestos

Public concern about asbestos surfaced in 1976 and since then media attention has highlighted the problems associated not only with blue asbestos (crocidolite) but with the more common white and brown forms. Asbestos was used in the past for building materials, thermal insulation lagging and, until the mid 1970s, in sprayed applications. Since the 1970s, manufacturers have concentrated on finding a range of non-asbestos alternatives. However, asbestos products have been so widely utilised throughout the UK that there is great public concern about the presence of asbestos in commercial, industrial and domestic premises, and public buildings.

Many local authorities are now undertaking regular inspections of buildings in which asbestos has been used. In general, no action is taken where asbestos sheeting, for example, is in good condition. Repairs are undertaken where small areas are damaged but where large areas are crumbling, cracked or damaged the material has to be replaced with a non-asbestos alternative. In some areas, asbestos monitoring and removal programmes are absorbing a great deal of local authority time and necessitate special measures for the protection of officers going in to inspect conditions or oversee remedial work.

The NSCA is keen to see that proper advice is made available by central Government so that enforcing agencies and the general public are fully aware of the problems associated with the use of asbestos products. It is particularly important to ensure careful control of asbestos removal from premises, and the protection of all involved during the process. Government guidance on proper ways of handling asbestos, and better public information on asbestos in the home and public buildings were identified as primary needs to help local authorities in their task of protecting the health of the community. Recent advice from DOE has gone some way to meet the requirement ("Asbestos Materials in Buildings" 1983).

Although most measurements of asbestos in the air, outside the workplace, show levels considered to be "safe" in the past, and certainly below the new control limits introduced by the Health and Safety Executive for workplace protection, there is widespread concern about the lack of an environmental control limit which would enable local authorities to access public exposure to asbestos. The NSCA recognises that, were such a limit to be set, it would be difficult and expensive to monitor the attainment of the standard in the ambient atmosphere. The Society considers that central Government should direct its attention towards giving authoritative advice on environmental exposure, control and monitoring.

7. Energy Policy and the Environment

The report produced by the Commission on Energy and the Environment, "Coal and the Environment", highlighted several points which are of particular concern to the Society. The possibility of a switchover to coal use on a considerable scale by industry in the UK strengthens the Society's belief that energy policy, particularly one involving increasing coal use, should have clean air as a priority. Grants have been available to industry from Government, to encourage conversion to coal. It is the Society's view that Government should apportion some of that grant for the proper training of stokers and boiler operators, so that emissions of smoke, grit and dust from coal fired plant can be minimised.

The increasing use of coal in a domestic situation is one which also concerns the NSCA. In recent years, research and development has concentrated on designing domestic smoke reducing appliances which claim to consume their own smoke when burning coal. The Society has yet to be convinced that such appliances are the answer to the domestic coal burning problem, especially as ordinary householders probably lack the expertise that the operation of such appliances to design standards demands. As already mentioned, the Society is concerned about the reversion to coal use in smoke control areas and considers that there is too large a gap between the cost of bituminous coal and that of solid smokeless fuels for the domestic consumer. With regard to the wider implications of increased coal burning on the atmospheric environment, the Society considers that the powers available to local authorities to control pollution need re-examining. It expects this matter to have priority in the review of air pollution control legislation currently being considered by Government.

8. Noise

This form of environmental pollution is of much interest to the Society and more time has in recent years been given to discussing the many problems which arise.

Transport is a major source of noise which can affect vast numbers of the population. It is interesting to note, for example, that there is no effective remedy open to a member of the public aggrieved by high levels of railway noise.

The Noise Insulation Regulations made under the Land Compensation Act in respect of road noise only apply in the case of 'new' roads or substantially reconstructed roads. They are restricted to compensating those affected, rather than protecting the residents' interests, and the compensation level of 68 dBA L_{10} (18 hr) is considered excessively high. The Regulations only apply to the protection of residents inside the house structure and do nothing about gardens and 'living spaces'.

The Society considers that there is a strong requirement for reviewing all aspects of the legislation on this subject, including a full re-examination of the criteria suggested as long ago as 1963 by the Wilson Committee on Noise. These, and other current noise issues, will be debated at this Conference on Wednesday afternoon. The Society is also concerned about the lack of progress in the development of the Quiet Heavy Vehicle which would be an important means of reducing the level of road noise at source. It appears that the technical knowledge is available or could be readily developed but that there is a lack of political will to pursue the project with any vigour.

Domestic premises are a major source of complaints about noise. Problems include anti-social behaviour by occupiers, barking dogs, and sound transmission through party walls, ceilings and floors. Many people would like to see an improvement in the Building Regulations regarding the design and construction of houses to reduce noise transmission from one dwelling to another. Particular problems are known to occur in the conversion of larger dwellings into separate self-contained flats and there appears to be no effective control over the need to provide adequate sound insulation between adjacent flats.

Low frequency noise and vibration are other areas where the Society would like to see more research into the problems, causes, effects, and remedies associated with this form of pollution which can cause real distress to some people.

CONCLUSION

Whilst much has been achieved over recent decades to significantly improve the environment and the air we breathe, it would be foolish to suggest that we should sit back and congratulate ourselves.

It is obvious that the general public are now much more conscious of pollution problems and can see the benefits that have been achieved in the past.

It is more difficult and costly to make significant improvements once the gross pollution problems have been reduced to a certain level. However, many of the pollutants can have serious effects on health e.g. lead and asbestos, and others may be extremely damaging, with long term effects on the environment. For these reasons it is important that the Society continues to press for improvements in air pollution control and the provision of adequate resources in terms of cash and manpower to see that effective monitoring and enforcement are carried out.

It is hoped that the many areas of concern to the Society highlighted in the preceding sections of this document will provoke a useful discussion and exchange of ideas with the panel which is ready to follow at the conclusion of this paper.

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1 NOVEMBER 1983
TORQUAY

ACID RAIN:
ECOLOGICAL EFFECTS – FOREST AND SOILS

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SUMMARY

"Natural" rainfall probably has a pH of 5.6 or a little lower, but the pH of rainfall in the northern hemisphere is now well below this. Acid rain (or better, acid deposition) consists of wet and dry forms; the dry form is preponderant near to sources of pollution, but in remote areas the two forms may become about equivalent. The concentrations at which pollutants (SO_2, NO_x and their derivatives) damage trees and other plants have not been established with certainty, either because of continuous variation in the field or because of interaction between two or more pollutants.

Tree canopies usually increase the ionic content of rainwater, as it passes through them, and may reduce or increase its pH. There is no clear evidence of damage to forests or to forest soils in Britain due to acid rain, though dry deposition in northern England has restricted tree planting in the past. Foresters are more concerned with the interactions between coniferous afforestation, stream chemistry, and stream biology, especially fish, than with damage to the forest.

The alarm in central Europe over forest decline may be justified but the causes are not clear. It is probably due to several factors acting together and at present it is believed that a combination of ozone and acid mist is responsible, but proof has yet to be provided. There is no evidence that soil damage from acid depositions is responsible for the large areas of declining spruce.

ACID RAIN

This popular term is better replaced by the more cumbersome 'acid deposition'. The bulk of the acidity in rain is due to compounds of sulphur and nitrogen, very roughly in the proportions two-thirds : one third, the ratio of nitrogen to sulphur having increased in recent years (Glass _et al_. 1980; Hileman 1981; Overrein 1983). Depositions are normally divided into 'dry', ie gaseous and particulate, and 'wet', ie rain, snow, fog, sleet etc.

'Pure' rain water has a pH of 5.6 (2.4 ug H^+1^{-1}) due to absorption of CO_2 to form H_2CO_3 (carbonic acid). Natural sources of sulphur (decomposition of vegetation, direct losses from soils, volcanoes) must also contribute to the acidity of rain so that the mean pH of 'natural' rain will be below 5.6. It has been suggested that 'natural' pH values might range from 4.5 to 5.6 due to the variability of the natural sulphur cycle alone (Charlson and Rodhe 1982). It is, however, estimated that about 90 per cent of all the sulphur falling on northern Europe is derived from man-made sources (Overrein 1983), so this far outweighs the natural inputs. Recently published information shows that much of the rain in the northern hemisphere has a pH below 5, sometimes as low as 4 (Anon 1983; Barrett _et al_. 1982; Fowler _et al_. 1982; Overrein 1983).

The acidity of rain is not well established for rural Britain, but the values shown in Fig. 1, although based on rather few stations, are generally accepted.

Figure 1 shows the strength of the acidity in the rainfall; another measure is the total amount of acidity, ie the weight of hydrogen ions falling each year. Because of the high rainfall in the west compared with the east, this gives a converse picture for Scotland, as shown in Figure 2.

Whether concentration or content is more important is still a matter of dispute. It is possible however that individual storm events of low pH are important for stream chemistry, but that long-term changes in the soil may be influenced more by the total load of hydrogen ions.

DIRECT EFFECTS OF POLLUTANTS

Dry deposition is most important close to sources of pollution where it is appreciably more than wet deposition. The dry deposition of SO_2 in Britain is shown in Fig. 3.

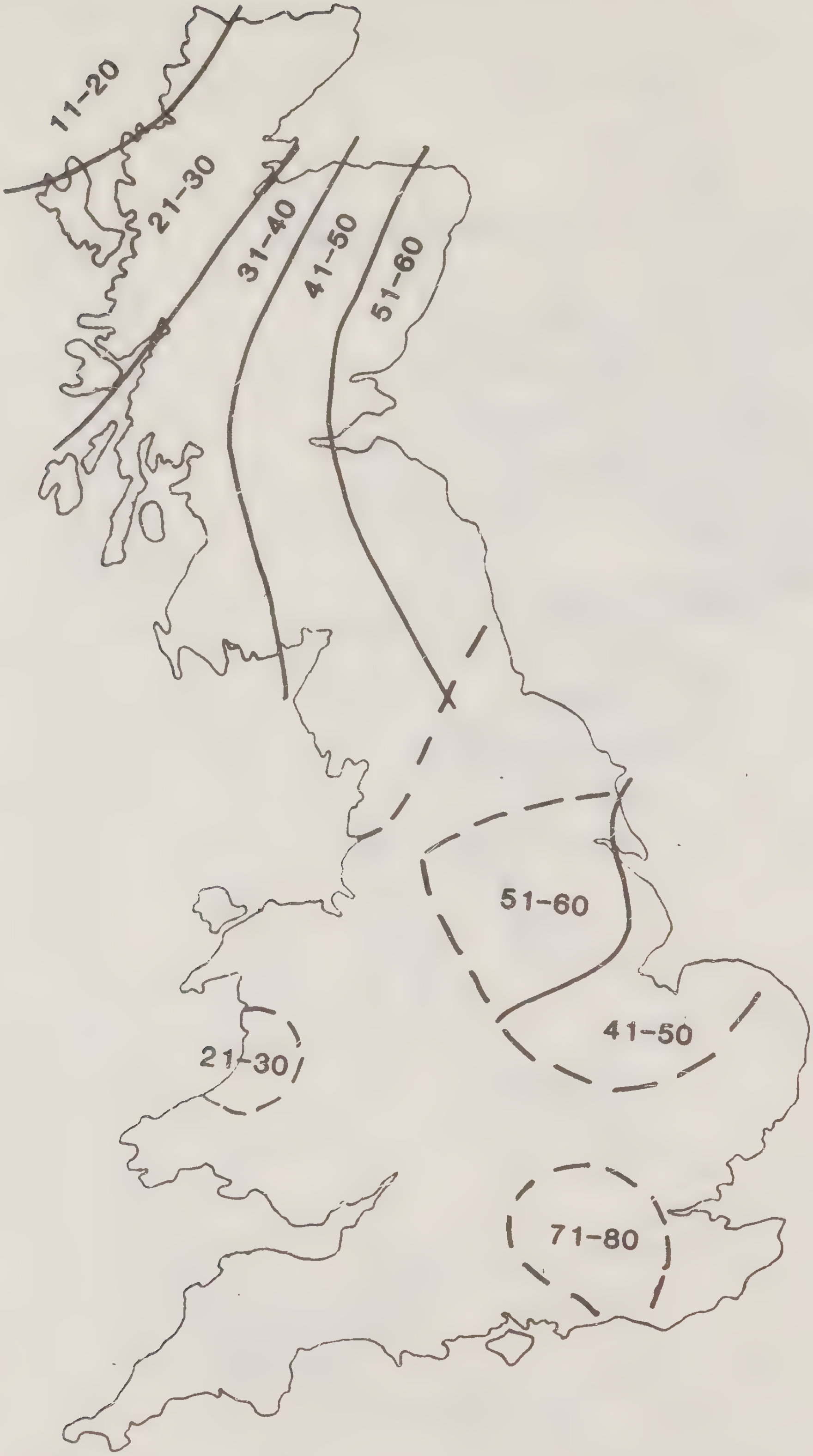

Figure 1 Rainfall weighted annual average hydrogen ion concentrations (ueq $H^+ l^{-1}$). Broken lines indicate the limits beyond which concentration boundaries have not been established. This and the next figure are based on rural measurements and the smaller scale variability close to large sources of air pollutants is not included. (From Barrett _et_ _al_. 1982).

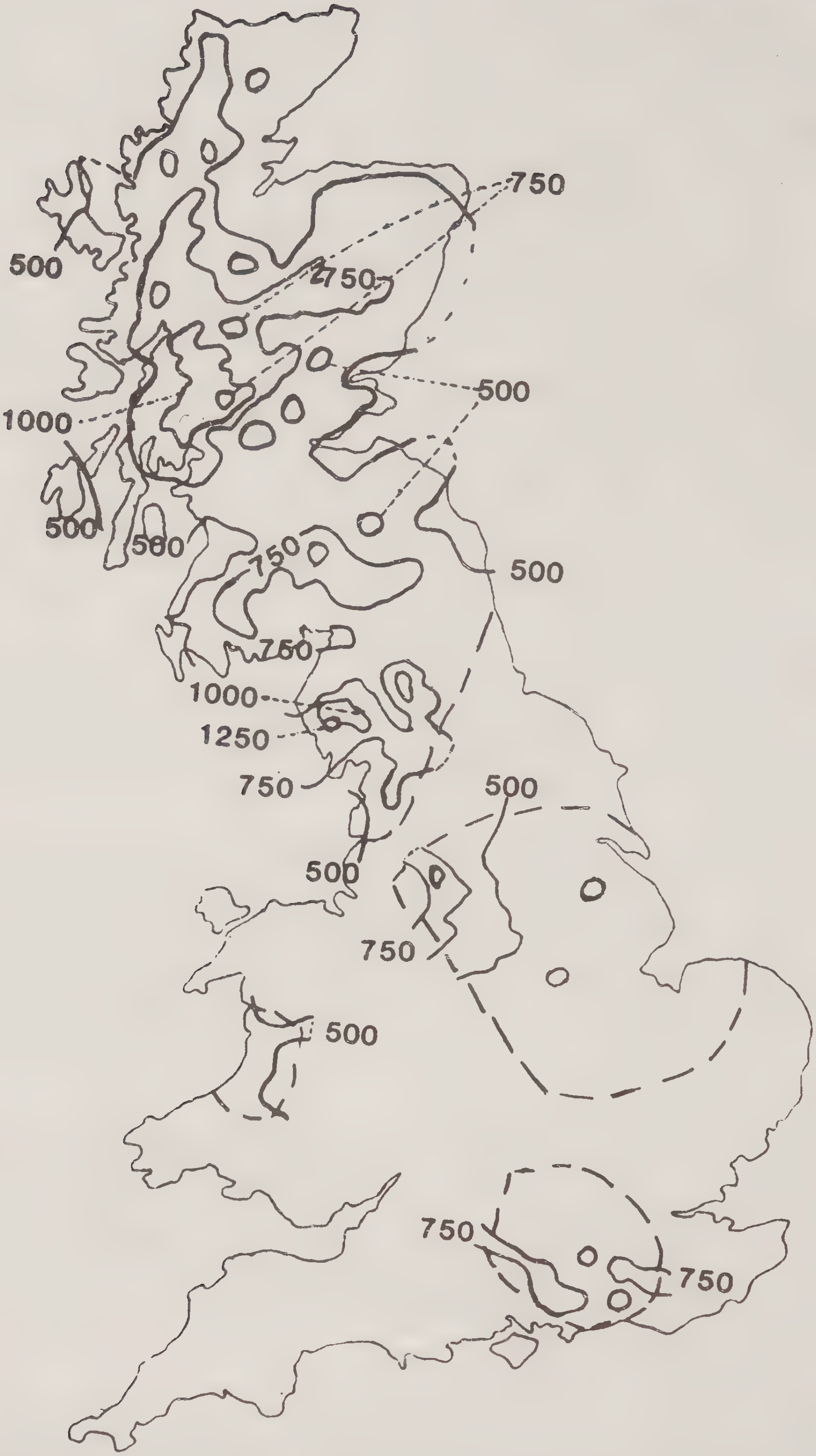

Figure 2 Annual deposition of hydrogen ions (g H^+ ha^{-1}); small enclosed areas have higher amounts, except for four instances indicated, where they are lower. (From Barrett *et al*. 1982).

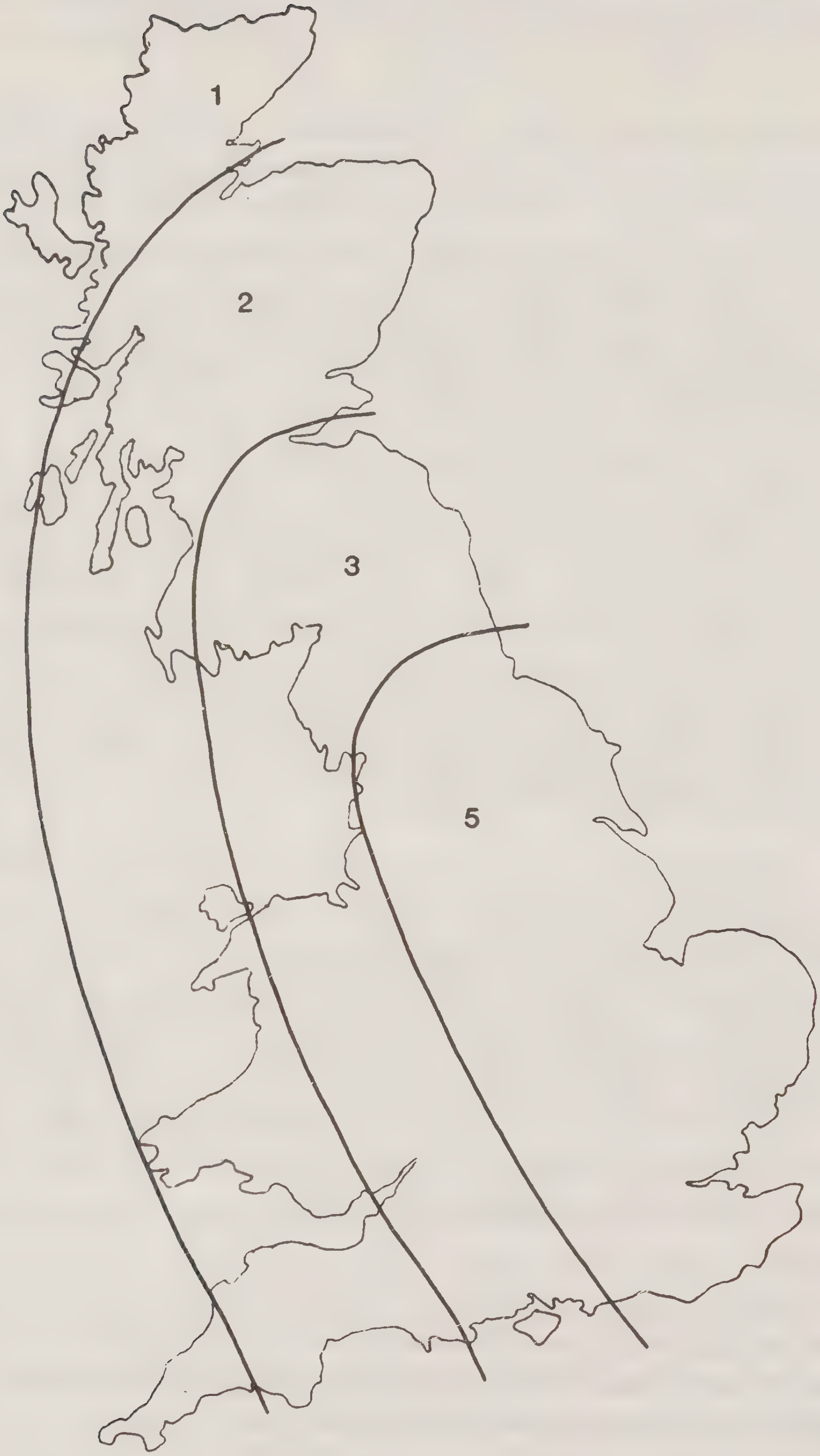

Figure 3 Dry deposition of SO_2 ($g\ SO_2\ m^{-2}y^{-1}$). The weight of S deposited is 0.5 of the weight of SO_2. (From Chester, 1983).

In the more remote and wetter parts of upland Britain dry deposition decreases relative to wet and the two may become roughly equivalent.

The concentrations of SO_2 in the air which actually affect plants seem to vary with the species or genus studied and with the conditions under which the observations were made or the experiments carried out. It would be expected that stomatal opening was highly correlated with pollutant uptake, but stomata are themselves apparently affected by pollutants. Experimental results are not consistent so that it is difficult to arrive at a clear understanding of the concentrations at which pollutants affect plants, apparently either because ambient pollution levels fluctuate continuously, so that peaks are concealed within the overall mean (or are missed altogether if recording is not continuous or very frequent); or because there are important interactions between two or more pollutants occurring together (eg Bell 1982; Whitmore and Freer-Smith 1982).

Both NO_2 and SO_2 are very soluble in water so they dissolve rapidly on the surface of the leaf. Once inside the leaf the nitrogen oxides form both nitrate and nitrite, the latter normally being converted to ammonium by the appropriate enzyme. It appears that the presence of SO_2 as well as nitrogen oxides prevents this last step and can thus be responsible for the damage sometimes reported when mixtures of the two gases have been used experimentally.

Most of the work in conifers has used concentrations of SO_2 above mean levels found in forests, but as mentioned, mean levels conceal short-term peaks. Effects in British forests are considered below.

Experiments with acid rain itself have produced remarkably few effects on trees. Abrahamsen and Tveite (1983), reviewing the evidence, consider that pH needs to be below 3 before there is much chance of direct damage to the trees. The same authors review experimental tree growth studies and again find no substantial evidence of effects on tree growth at the acidity levels in present precipitation.

FOREST CANOPY INTERACTIONS

There is a great deal of evidence on the way rainfall quantity and quality can be modified by forests. We know, first of all, that forests intercept and re-evaporate between 30 and 40 per cent of the incoming rainfall, which thus never reaches the ground (eg Calder and Newson 1979). While this has important implications for the water engineer, it also has some consequences for precipitation chemistry. The trees intercept the rain with its pollutants, but the re-evaporation will be mostly water with the majority of the acidic substances remaining behind on the leaves or needles. It follows that the total rainfall for the year descending to the forest floor, comprising throughfall and stemflow, will be more acid in terms of concentration than the incident rainfall.

Tree crowns are known to have a tremendous capacity for filtering out aerosols from the atmosphere, much attention having been paid to this recently in Germany (eg Hofken 1983). It follows that the total amount of pollutants as well as their concentration may be increased under forests.

There is however some contrary evidence from less polluted areas. Miller (1983) has produced evidence of reductions in inputs of H^+ at four out of six spruce sites in north Britain and more recently Miller & Miller (private communication) have shown that, taking five years of measurements from the same six sites, they find on average a reduction of hydrogen ion input at all of them (Table 1). Miller (1983) also shows a marked seasonal variation in the pH of throughfall and stemflow at a relatively polluted east Scotland site, while no such trend was observable in a relatively unpolluted west coast site.

Table 1

Acid content of incident rainwater, throughfall and stemflow measured over five years at various stands of Sitka spruce in Scotland and Cumbria.
(H.G. Miller and J.D. Miller, priv. comm.)

$\text{eq } H^{+} \text{ ha}^{-1} \text{ year}^{-1}$

	Leanachan	Kilmichael	Strathyre	Elibank	Kershope	Fetteresso
Incident rain	440	970	480	750	750	640
Throughfall	80	130	230	220	420	410
Stemflow	60	260	150	60	240	180
Throughfall + stemflow	140	390	380	280	660	590
% change	-68	-60	-21	-63	-12	- 8

Table 2

Mean pH of water at various points in different ecosystems for the year November 1980 to November 1981 at Glen Tanar in north-east Scotland.
(Miller, 1983)

pH of bulk precipitation 4.6
pH of filter gauge water 4.4

Water flux	Vegetation Cover					
	Heather (*Calluna vulgaris*)	Scots pine (*Pinus sylvestris*)		Sitka spruce (*Picea sitchensis*)	Japanese larch (*Larix kaempferi*)	Birch (*Betula* spp.)
		old	young			
Throughfall	–	3.9	4.7	5.4	4.8	4.8
Stemflow	–	3.1	3.5	3.9	3.7	3.9
Beneath ground vegetation	4.5	5.5	5.5	*	4.7	6.4
Beneath humus	4.0	3.6	3.8	4.4	4.6	5.1
Below rooting zone	5.6	4.4	4.7	5.5	4.9	6.6

* No ground vegetation grew beneath the spruce

The tree canopies themselves can contribute to the ionic content of rain water and can contribute organic acids as well as simple cations and anions. The cations and anions however, which are leached from leaves or needles by rain, are just being cycled: there is neither loss nor gain involved in this process. Furthermore, they exchange for hydrogen ions, which explains the rise in pH shown in Table 1.

It also appears that different species can affect the throughfall in different ways. For example Miller (1983), in a study of the effects of different species on throughfall and stemflow and also of the moderating effects of ground vegetation, humus and soil, found that old Scots pine had the most acidifying effect, while Sitka spruce raised the pH of the throughfall more than either larch or birch (see Table 2).

The conclusion from the literature is that effects of tree canopies and vegetation on the quality of rainfall can work either way and cannot be forecast with certainty.

FOREST DECLINE IN CENTRAL EUROPE

There has been a great deal of publicity and sensationalism in the popular press both in Germany and Britain over the alleged effects of acid rain on Central European forests (eg article in the Sunday Times, 5 June 1983, "The Rain that Kills"). There is no doubt that there is decline and damage not only to large areas of Silver fir (_Abies alba_) forest, which has been recorded in previous centuries, but also to Norway spruce (_Picea abies_), which appears to be a new phenomenon (Binns & Redfern, 1983). A survey made in 1982 (Anon 1982) estimated that over ½ million hectares of forest in West Germany are affected by decline and it is expected that a similar survey in 1983 will show a much larger area now damaged. Most of this damage is in high elevation forests, over 600, 800 or even 1000 m above sea level, and is frequently (but not always) associated with marked magnesium deficiency (eg Binns and Redfern 1983). What is puzzling is that the decline is in areas where the pollution levels, as judged by concentrations of SO_2, are relatively low. Ulrich and his co-workers (eg Ulrich et al. 1980, Ulrich 1983) have suggested that the consequence of acid rain on the soil will be widespread death of the forest. This is attributed to the loss of calcium and magnesium due to acid pulses from the mineralisation of root and humus residues, made more extreme by acid rain, which eventually results in the liberation of aluminium (Al^{3+}). This aluminium, when not buffered by calcium, damages roots and starts the decline. There is, however, no evidence from studies in E. Bavaria and the Black Forest (eg Zottl and Mies in press, Rehfuess 1983) that soil aluminium is involved in the dieback of spruce.

Furthermore, experiments in water culture by Miller in Scotland on sitka spruce, Abrahamsen in Norway on Norway spruce and Hutchison in Canada on pines, suggest that these conifers tolerate Al^{3+} concentrations up to 40 ppm, with much lower calcium concentrations.

An explanation of this widespread and very worrying phenomenon has yet to be produced and it is agreed that there is no one single, simple cause of the decline and it seems unlikely that SO_2 is the cause of the recent spruce decline as concentrations have been decreasing since the mid 1970's. Stress following the extreme drought in 1976 has been suggested as having some influence and the current German hypothesis (eg Prinz et al. 1982) is that a combination of ozone and acid mists may be responsible for the damage. It is noteworthy that the forests affected have a reasonable population of lichens (Prinz et al. 1982), which are sensitive to SO_2 but not to acid rain (Mellanby, private communication). There are very few measurements of pollutants, particularly O_3, in the remote high elevation forests where damage is worst and where access is difficult, particularly in winter. There is a great deal of research now going on and one hopes to see a considerable increase in understanding within the next two years. It is important to stress that a reduction of SO_2 emissions on their own may well be insufficient to stop the decline of these forests if ozone is indeed one of the primary causes.

EFFECTS ON SOILS

It has already been stated that there is no evidence of soil aluminium toxicity associated with the German forest decline. However the longterm effects of continued loading of soils with more than normally acid precipitation is of concern, particularly on those soils derived from acid geologies which are relatively poorly supplied with calcium and magnesium. It is worth mentioning that most agricultural soils are limed periodically in the course of normal farming so that the impact of acid rain is completely overshadowed by these massive additions of calcium. Indeed, the potential buffering power of even relatively acid rocks is very high. Bache (1983) for example has calculated that there is enough calcium in a 1 mm thickness of granite to neutralise about 200 years' worth of acid rain at pH 4.3. This, however, begs the question of time that such acid rain is in contact with the granite or the soil. A great deal depends on the way the rain arrives and how it travels through or over the soil to drains or forest streams. In a natural, unmanaged forest, without artificial drainage channels, most rain passes through the soil before it reaches streams and there is time for the normal chemical reactions to take place. The sulphate ions have their accompanying hydrogen exchanged for calcium or magnesium, which in due course are replaced by weathering of the soil minerals.

If however there is extreme concentration by, for example, stemflow, then it may be that the acid concentration and speed of movement are too great to allow these reactions to take place. This has consequences for the soil water reaching drains and forest streams, which will be dealt with in the following paper by Kinsman. There is the further point, recently explored by Nilsson _et al_. (1982) that forest growth by itself is an acidifying process, because there is an imbalance between the positive cations and the negative anions taken up by trees, so that hydrogen ions have to be released in the soil to maintain electro-neutrality. These however will be uniformly distributed throughout the soil in the rooting zone and, in a natural forest, the phenomenon is temporary because the death and eventual decay of the trees returns the cations to the soil. Continued harvesting of forest crops, however, will tend to perpetuate this acidity and it should be taken into account in long-term studies of the effects of forestry on soil properties.

BRITISH FORESTS AND ACID DEPOSITIONS

The distribution of managed forest in Britain as at 1976 is shown in Figure 4. It is unlikely to have changed much since then.

Figure 5 shows the areas of high rainfall in Britain and it will be seen that, apart from a few exceptions such as East Anglia, the New Forest, the Forest of Dean and some areas along the eastern seaboard of north Britain, the bulk of the production forests lie in areas receiving more than 800 mm of rain a year. It follows, from what has been said above about sulphur depositions and hydrogen ions, that if there were problems in production forests, they would be due to high loads of moderately acid rainfall.

It is also important to consider the distribution of forests in relation to SO_2 levels in the air. Figure 6 shows a simplified map of mean annual SO_2 concentrations over Britain. The high concentrations associated with the major industrial areas are seen and, remembering the physical map of Britain, it is also seen that most of the large production forests are in areas of relatively high lying land. Furthermore, most of the high lying land has a fair proportion of managed forests. Some areas one might expect to have forest on, such as Dartmoor, Exmoor and the Lake District, are only lightly planted because of pressure from landscape and conservation groups. The most surprising feature is the lack

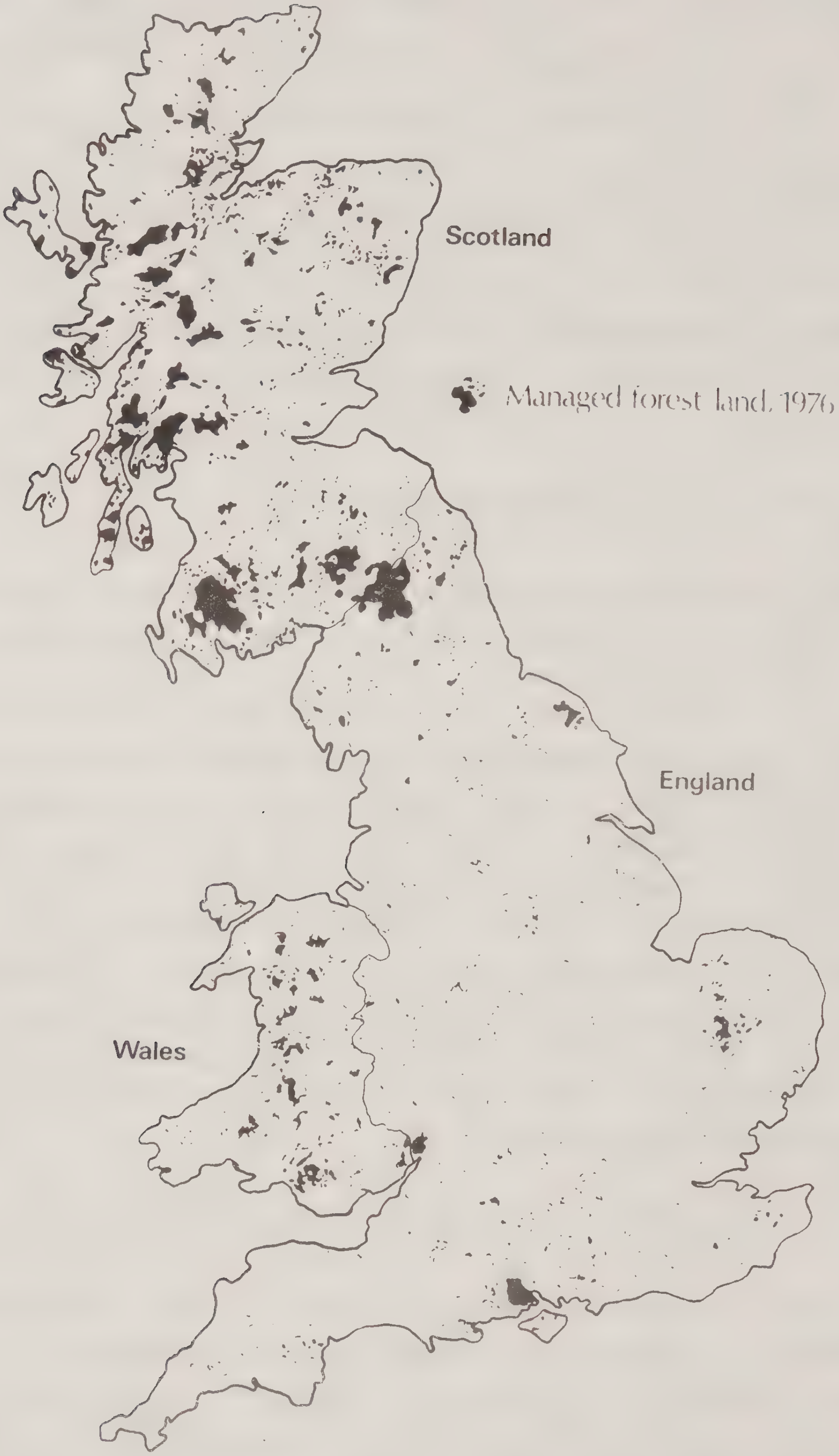

Figure 4 Managed forest land in Britain; Forestry Commission land as at 31.3.76, private land as at 30.9.75. Some islands with little forest have been omitted and some small forests do not show up on this scale.

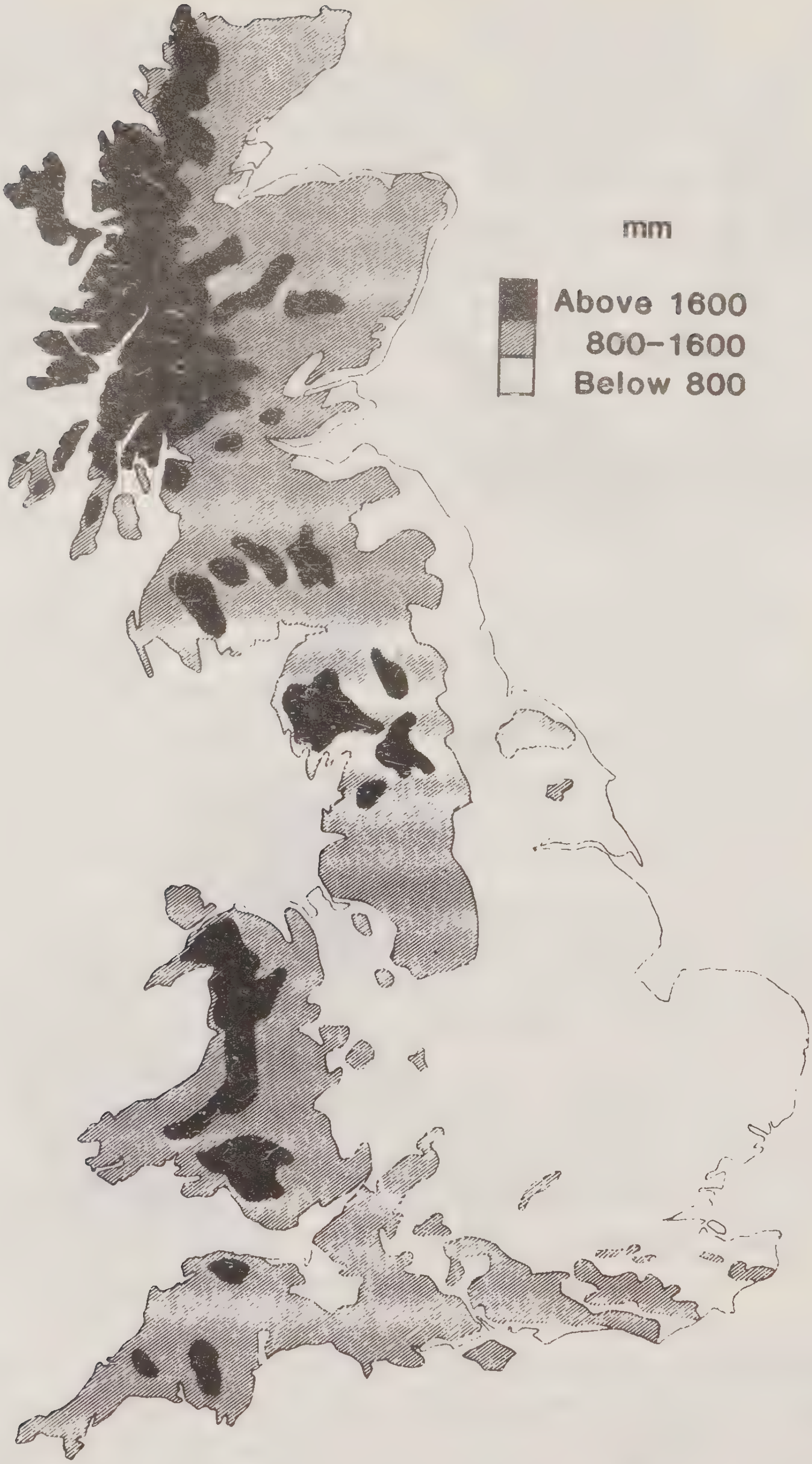

Figure 5 Land in Britain receiving, on average, more than 800 mm and more than 1600 mm rainfall a year. 1941-1970. (Modified from Barrett et al. 1982).

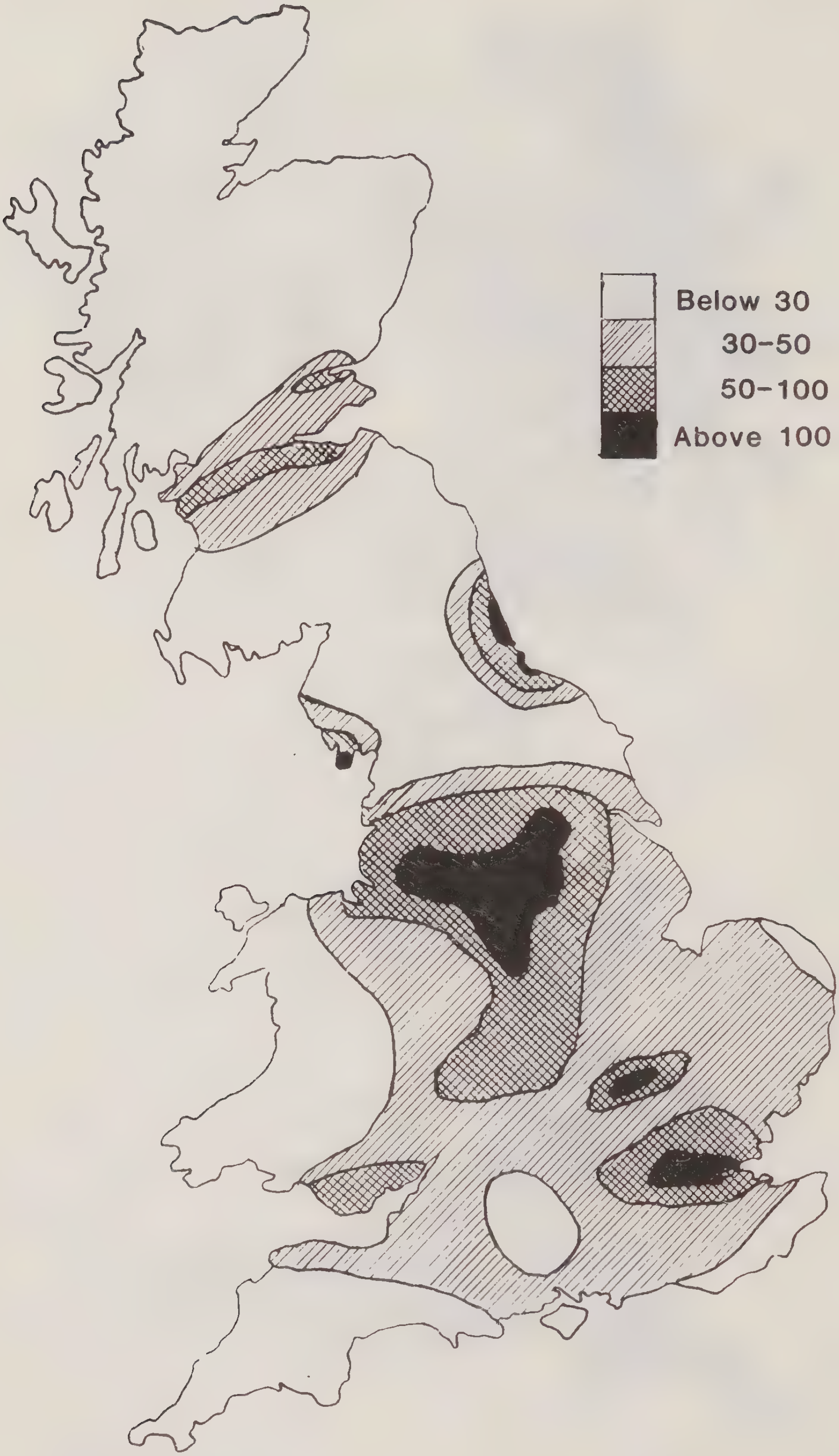

Figure 6 Simplified map of annual mean SO_2 concentrations, based on 1974 data (ug m^{-3}). Current concentrations are probably 20 to 25 per cent lower.

of forests in the middle and southern Pennines, compared say with the Borders or south-west Scotland.

The Forestry Commission has many experiments in the southern Pennines, but nearly all of these failed until quite recently. It seems clear that direct pollution damage was responsible for the failure of Sitka spruce, which is the tree most suited to the region on soil and climatic grounds. More recently, since the mid-70s, some of these earlier experiments have started to grow and some new ones appear to have been more successful. It seems inescapable that this change has been brought about by the reduction both in smoke and in SO_2 in this region which has taken place since the mid-70s.

Apart from this one major region, there is little evidence of damage to forests in Britain from pollution or from acid rain, other than from known point sources of intense pollution. Some 60 per cent of managed forest in Britain is in the relatively unpolluted uplands, and only 5 per cent (perhaps 10 per cent in England) is in regions where adverse effects of pollutants might be expected. There is as yet no evidence of damage to soils from pollutants; indeed Skeffington (1983) has shown that oak, Scots pine and birch are growing, apparently healthily, in one forest in south east England where the soil aluminium is quite high compared with the values quoted by Ulrich. This is not to say that continued acid depositions might not in the very long run cause sufficient leaching of calcium and magnesium from the soil to cause damage, only that no such damage has so far been found.

It is perhaps surprising that foresters in Britain have been more concerned about the apparent interactions between forest and stream-flow which have been reported by for example Harriman and Morrison (1982). Research to explain these apparent forest effects is being encouraged, but is unlikely to produce results for some years.

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ACID RAIN:
ECOLOGICAL EFFECTS OF WATER COURSES AND FISH

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INTRODUCTION

The waters of the earth's surface cycle through the atmosphere in vapour, liquid or solid forms and during these processes interact with the other components of the atmosphere; for example, the major gases, oxygen and nitrogen. Oxygen dissolved in the waters of lakes and rivers is crucial for all but the most primitive forms of animal life, whereas dissolved nitrogen is largely unreactive. Minor gaseous components of the atmosphere may react in more complex ways with water droplets, CO_2 for example producing HCO_3^-, $CO_3^=$ and H^+ ions. Precipitation is thus typically not a neutral solution of pH 7, containing merely dissolved atmospheric gases, but is a somewhat acid solution containing a variety of chemical species. If CO_2 were the only chemical component affecting the pH of precipitation, then values close to 5.6 should occur in unpolluted areas (the man-induced increase in CO_2 concentration in the global atmosphere would have changed this value very little). However, a host of other components in gaseous and even in solid form exists in the atmosphere and reacts with precipitation; for example the dissolution of limestone dust particles or of naturally produced ammonia will result in alkaline precipitation, whereas naturally produced volatile sulphur compounds tend to make precipitation more acid. Taking all these effects into consideration Charlson & Rodhe (1982) have suggested that the pre-industrial pH of precipitation probably averaged around 5, but ranged from 4.5 to 8.

Today, however, in many northern temperate areas precipitation is markedly more acid, mean pH values of 4.0 to 4.5 being quite common, and this has come about largely as a result of industrial and domestic emissions of sulphur, nitrogen and chlorine compounds. The fall-out pattern of these pollutants is often complex, with precipitation events of intense acidity sometimes occurring. Over the past decade or so, some European sites have shown increases in precipitation acidity whereas others have shown decreases. In the English Lake District, the Freshwater Biological Association records

(Sutcliffe 1983) demonstrate no change in the acidity of local precipitation over several decades, values averaging 4.4.

The input of acidity to any area is a function of the quantity and nature of precipitation and the availability of acidic aerosol particles. The presence of taller vegetation, such as tress, can play an important role in intercepting such aerosol particles.

The aquatic habitats of most interest in relation to acidification are the freshwater environments of streams, rivers and lakes, rather than estuaries or the sea; and of the freshwater environments it is those characterised by soft waters which are most susceptible to change. Freshwater environments have many of their chemical and physical characteristics constrained by reactions which take place in the terrestrial environments of their catchments. The rocks and soils, the geomorphology, the terrestrial vegetation, all play important roles in the hydrological and biogeochemical characterisation of the catchment effluents which enter the streams, rivers and lakes, by more or less convoluted pathways. As the surface area ratio of stream or lake to total catchment is generally rather small (< 0.1, often < 0.01) the chemical characteristics of freshwaters often only feebly mirror those of incoming precipitation. However, in some upland areas with high precipitation, relatively unreactive rocks and thin soils, and where catchments are small, surface water chemistry may closely resemble local precipitation.

Catchment interactions usually buffer much of the H^+ input but in more unreactive catchments, such as those underlain by granitic rocks for example, little buffering may occur. Since post-glacial times there has been a slow acidification of many northern temperate soils as a natural result of the input of acidic precipitation. However, the acidity of modern precipitation is 5 to 10 times greater than that of pre-industrial times and certain soils and aquatic environments are now showing the effects of this increased acidic input.

Galloway (1983) has suggested that the H^+ derived from H_2SO_4 (SO_2 pollution) will lead to long-term (decades) acidification or alkalinity reduction, whereas the H^+ derived from HNO_3 will cause episodic short term (weeks) reductions, superimposed on the long-term sulphate reduction of alkalinity. These episodic reductions will occur predominantly during increased winter base flow periods and during spring snow melt due to reduced residence times of NO_3^- in soil systems and reduced winter rates of biological uptake on the catchment. Thus predictable seasonal controls and unpredictable, aperiodic events (including meteorological events) will lead to pH variability in catchment effluent input into streams and lakes. It may well be that these short term, intense spikes of acidity play a very major role in effects on aquatic organisms.

The potential sensitivity of a freshwater to acidification has been well reviewed by Galloway and Dillon (1983). Biological responses to acidification have been noted at alkalinities of < 100 µeq l^{-1}; the maximum input of excess acid in various areas of the U.S., U.K., and Scandinavia is about 100 µeq l^{-1}, except for some short term events; thus those waters with an initial alkalinity of < 200 µeq l^{-1} are potentially the sensitive ones. The alkalinity is derived either from geological sources of rock weathering or may be internally produced within a lake by primary production and decomposition processes. This latter source of alkalinity may be very important and thus the nutrient status of soft water lakes is rather critical. If one uses this measure of acidification sensitivity then several of the large Lake District lakes, for example, are very poised; relatively small increases in H^+ input in precipitation or decreases in the neutralization capacity of the catchments might drive them to appreciably lower pH values, values at which there would be considerable biological changes (using chemical data of Carrick & Sutcliffe, 1982). Smaller lakes and tarns and especially headwater streams will, of course, be most sensitive, because they are frequently dominated by the chemistry of precipitation input; their alkalinity is derived almost solely from rock weathering and values are often relatively low.

SUMMARY OF EFFECTS ON AQUATIC PLANTS AND ANIMALS

Studies of several kinds have been made in order to determine the effects or likely effects of acidification on aquatic biota (Magnuson et al. 1983): (a) naturally acidic ecosystems, covering a range of pH environments; (b) ecosystems which have become more acid in recent times; (c) experimentally manipulated ecosystems; (d) laboratory studies, generally of a physiological nature.

The subject of anthropogenic acidification is receiving much study and various review papers and symposium volumes have appeared over the last few years. Acidification effects on the chemistry and biology of aquatic environments form chapters in a very recent synthesis (May 1983) of the literature by the United States Environmental Protection Agency, as part of its National Acid Precipitation Program (Ed. Linthurst, 1983). The chapter on Effects on Aquatic Chemistry is 162 pages in length with 25 pages of references and the chapter on Effects on Aquatic Biology is 203 pages in length with 38 pages of references. I refer readers to this publication for further detail and for the primary sources for some of the statements made in this paper.

Macrophytes

There are few studies describing direct effects on macrophytes, although some studies have shown a reduction in higher plant diversity with decreasing pH. Some Swedish lakes show a development towards Sphagnum dominated macrophyte communities with time, but this does not appear to be a general development in acidified lakes. There is no clear effect observed on changed productivity of macrophytes. There are, however, increases recorded in the metal contents of plant tissues, especially of Al, Fe, Pb and Cu, whereas Mn, Zn and Cd are decreased. The uptake of most of these metals was by active metabolism and metals were largely derived from the sediments, but some proportion was possibly adsorbed onto external surfaces and derived from the lake water.

Periphyton

The periphyton comprises the algal community living attached to surfaces of sediments, stones and plants and it forms an important food source for larger invertebrates. Studies suggest considerable differences in species composition between different pH environments. In lakes with pH below 5, mats of blue-green or green algae have been recorded, although there are often considerable differences between algal communities living in different lakes of the same pH. There are also marked differences in the diatom communities in response to pH; benthic diatoms begin to dominate over planktonic forms as pH decreases, and the changing diatom flora has been of value in studies of lake sediment cores, where it can be used to interpret changing pH history of a lake.

Phytoplankton

Extensive studies have shown that under more acid conditions phytoplankton communities change their species composition, in particular reducing their diversity. These effects are especially large between pH 6.0 and 5.0. Although certain species drop out from all classes as pH falls, because of disproportionate losses from certain groups the overall dominance changes. Dinoflagellates commonly dominate in acidic lakes although in some acid lakes green algae dominate but with dinoflagellates still abundant. A few acid lakes are dominated by blue-green algae, especially humic acid dominated lakes. Productivity in acid lakes is commonly as high as in neutral pH lakes and to date there is no clear indication of any direct link between low pH and primary productivity.

Microbes

There is no specific information on pH effects on benthic protozoa. There are some data on bacterial decomposition rates under different pH conditions and several studies note a general decrease in rate as pH decreases. Many studies, however, are equivocal. Some authors have proposed that under more acid conditions fungal decomposition begins to dominate but this conclusion is considered questionable by some workers.

Zooplankton

Zooplankton communities are significantly affected by pH, there being a marked decrease in diversity at around pH 5.0 - 5.3. In general, low pH zooplankton communities are residuals of communities typical of neutral pH lakes in the same area, the dominant species in acid lakes being important members of the communities in neutral waters. There is little or no evidence of invasion of new species into acidified lakes. Some rotifers are particularly common in acid waters. However, several species of cladocerans seem very sensitive to low pH; for example, many species of *Daphnia*. However, the cladoceran genus *Bosmina* commonly counterbalances this reduction in daphnids and certain copepods often become abundant in such waters. There is little or no information on the relationship between pH and zooplankton productivity or biomass.

Some of the changes noted above in zooplankton communities may not be related simply to tolerance of low pH conditions but may reflect changing community interactions; changing predator-prey relationships, for example. It has been suggested by several authors that in the absence of planktivorous fish, the zooplankton community becomes dominated by large-bodied species, those species which were earlier preyed upon preferentially by the fish. Some of these larger zooplankton feed on smaller elements of the zooplankton community and thus the complexion of the resultant community can be significantly altered.

Zoobenthos

Many benthic invertebrates are very sensitivie to pH, those forms living on the substrate, such as snails, mussels and stoneflies, being more sensitive to low pH than those which live actually within the sediments. Again, there is a general observation of a decrease in diversity as pH declines, particularly at pH values below 6. At even lower pH decreases in biomass have been reported. Benthic crustaceans show a wide range of responses to pH, some being tolerant of quite acid conditions. Aquatic insects are an ecologically important group of invertebrates in lakes and streams; the mayflies (Ephemeroptera) are very acid sensitive, whereas the dragonflies and damselflies (Odonata) are much more resistant to low pH. Stoneflies (Plecoptera) and caddisflies (Trichoptera) both show a wide range of responses but many forms are affected at pH values of 4.5 to 5.5. Some groups of insects are, however, very tolerant of acid conditions, including midges (Chironomidae), and black flies (Simulidae). Attempts have been made to interpret the sensitivities of insects to pH by considering taxa in functional groupings or in microhabitat communities. Such a consideration has, for example, shown that infaunal communities are less affected than epifaunal communities and that it is the epifaunal forms with filamentous gills which are most pH sensitivie.

Molluscs are very sensitive to low pH, with few species tolerating pH below 6, although Ca^{++} concentrations seem particularly important for these animals.

Fish

Loss of fish populations from acidified streams and lakes has been widely reported although many of the earlier data are questionable, detailed studies rarely having been made. Below pH 6 some fisheries become poorer and in environments where pH is consistently below 5 fish are usually absent. However, there is great variation in the pH at which fisheries are affected and it is becoming clear that the concentrations of physiologically important elements such as calcium are critical. In addition, the toxic effects of aluminium released from acidified soils can also be severe. Some of these stresses affect adult fish; others affect juvenile or egg stages more severely. Availability of food supplies may also be marginal in some acidified environments.

CONCLUDING REMARKS

The accurate measurement of pH in poorly buffered waters is difficult and uncertainties between operators and between electrodes can be relatively large. However, the range of pH in the environments under consideration and the pH changes recorded in some locations are much larger than these inaccuracies. We certainly need to develop instrumentation and methods which will provide more accurate measures of pH. This need will become pressing when we try to determine changes in pH which might follow from any emissions control programme. In streams, in particular, we need ideally to monitor pH continuously because pH spikes of minutes' duration may be the critical events for some components of the biota. The biota in the stream is responding continuously to the variations in the environmental conditions, whereas our most frequent measurements rarely describe the stream environment for more than 1 in 10^3 or 1 in 10^4 of the time (daily or weekly measurement frequencies respectively).

The onset of enhanced acid inputs to surface environments occurred presumably in the mid-19th century when industrialisation got underway in Europe and North America. There are no records of water chemistry or detailed descriptions of aquatic communities predating this onset. The assumption that pristine aquatic environments, unaffected by enhanced acid precipitation, can be found today is surely questionable and thus we have no firm base-lines to work from. Past pH measurements generally post-date the 1920s; are often only spot or short series measurements; are commonly for surface waters in summer at which time annual pH values are at their maximum; and the methods themselves were not very precise. Diatom stratigraphy may offer the promise of more precise determination of both the onset of pH change for any specific lake and the actual extent of the pH change. Superimposed on the acid precipitation effects on surface water environments are alkalinity changes brought about by changing levels of eutrophication; these changes have been mostly in the direction of increasing eutrophication, the effect of which will counter acidification.

To date, most changes in aquatic biota have been considered to result from increasing H^+ concentration alone, although fish studies in particular have more recently emphasized the effects of Al and physiologically important cations such as Ca^{++} and Na^+. These studies apart (for example, Brown, 1982), there has been little attempt to grapple seriously with the real causative factors controlling absence of particular faunal or floral elements from particular aquatic environments. Until the causative factors are better understood the application of control, preventative or ameliorative measures will be a high-risk activity. Many past studies have produced correlations which have been presented or interpreted as cause-effect relationships, yet it is questionable whether this is true. The interactive, dynamic nature of aquatic communities makes the interpretation of changes affecting one component very difficult.

The sensitive water bodies can be fairly readily identified, and these have alkalinities today below 100 ueq l^{-1}; those with values 50 ueq l^{-1} are particularly precariously poised and their pH could change quite drastically in response to seemingly small additional inputs of acidity. Those waters whose pH drops below about 6, even for only limited periods, are likely to show the most severely affected plant and animal communities.

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ACID RAIN:
INTERNATIONAL ASPECTS AND UK POLICY

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1. Over the last year or so the so-called 'acid rain' problem has been the subject of intense international activity in both political and scientific contexts. My aim in this talk is to give an appreciation of the international dimensions of the problem and of the present UK position.

2. A few words to set the historical perspective may be helpful. It was of course recognised many years before 1972 that polluting emissions could lead to acid deposition and environmental damage. However, it was in that year that the phenomenon first acquired international political significance as a result of the Swedish Case Study, "Air pollution across national boundaries: the impact of sulphur in air and precipitation", which was presented to the UN Conference on the Human Environment at Stockholm.

3. The period of the early 1970s was one of intensive research, particularly in the Scandinavian countries. The UK was involved in research on atmospheric transport and was an active participant in collaborative studies under the aegis of the Organisation for Economic Cooperation and Development on the long range transport of air pollutants. The OECD work led to an international agreement to cooperate in a continuing programme of monitoring and evaluation. The resulting European Monitoring and Evaluation Programme (EMEP) has been in operation since 1978; it now operates in 21 countries with a total of 75 monitoring stations. All the countries contribute measurements of sulphur dioxide and sulphate, and some operate an extended programme covering nitrogen compounds. Through the EMEP programme our estimates of the emissions and depositions of sulphur dioxide between countries in the region have been improved progressively.

4. Continuing concern about the problem of 'acid rain', in particular in the Scandinavian countries but also in North America where similar adverse effects attributed to acidification were reported, led eventually, in 1979, to the signing of the UN/ECE Convention on Long Range Transboundary Air Pollution. This important instrument

requires the Contracting Parties, "taking due account of the facts and problems involved", to "endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution." The Convention provides for cooperation between the Contracting Parties in research, monitoring and the exchange of information on air pollution matters. The Convention was ratified by the UK, and by most other Member States of the Community, in July last year and entered into force in March of this year. However, international cooperation under the Convention started much earlier on an interim basis. Since 1979 the UK has become increasingly involved with other countries in studying the effects of acid deposition on crops, forests, freshwater and fish and on materials, and the costs and likely effectiveness of possible control options. This work is now continuing on a formal basis under the Executive Body established to direct implementation and development of the Convention. With the entry into force of the Convention, EMEP is becoming an integral part of operations under the direction of the Executive Body.

5. In essence the Convention reflects the UK approach to this, and other pollution problems; that is, insistence on the importance of measurement and research, and hence scientific understanding, to provide a sound foundation for decisions on control action. It must be said that this patient, scientific approach has come to be regarded by many people as not measuring up to the urgency of the acid rain problem as they perceive it. Over the last year or so - in particular since the Stockholm conference on acidification held in June last year - the view has increasingly gained ground that the time for action has come; that the causes and damaging effects of acid deposition are sufficiently established to require immediate international action to curb emissions.

6. The Stockholm conference clearly demonstrated that acid rain had become a substantial political issue. The conference concluded that estimates show a significant

increase in acid deposition in recent decades, due primarily to increases in emissions of sulphur dioxide and oxides of nitrogen through the combustion of fossil fuels. The conference agreed on the need for urgent, concrete action, within the framework of the Convention, "to reduce air pollution including long-range transboundary air pollution"; this action should include consultations "with the purpose of establishing concerted programmes for the reduction of sulphur emissions taking into account environmental needs, socio-economic priorities and energy considerations". Similar action should be taken as soon as possible to reduce nitrogen oxide emissions from both stationary and mobile sources. The "best available technology which is economically feasible" should be applied to reduce emissions. The basis for the increased urgency reflected in these conclusions is not readily discernible in the careful, qualified findings of the expert scientific groups whose discussions preceded the Ministerial Conference. It is of interest to note in particular the findings that unequivocal evidence of direct, damaging effects of acid rain on tree growth had not yet been obtained; and that a direct relationship could not be established between emissions in one country and deposition in another.

7. The momentum generated by the Stockholm conference was maintained by other, subsequent international developments. Within the European Community, and during the time of the West German Presidency, proposals were put forward for two major new directives in the field of industrial air pollution control. The first of these, which is now under consideration within the Council machinery, is concerned with general control measures aimed at preventing or reducing air pollution from specified categories of industrial plant. The potential impact of this draft directive so far as the acid rain question is concerned rests on a provision for Community-wide emission limits to be set, "if necessary", for certain specified pollutants, which could include sulphur dioxide or oxides of nitrogen. Emission limits for these pollutants (and also for particulates) are in fact specified for major combustion plants in the

second of the proposed new directives, which is currently at the stage of expert consideration by the European Commission. For sulphur, the limits would imply the use of flue gas desulphurisation or equivalent technology at power stations. The limits specified in the first draft of the proposed directive reflected those that were being considered at that time for adoption in West Germany; this action stemmed from the growing concern in that country with the damage to forests which was then mainly attributed to acid deposition due to sulphur and nitrogen oxide emissions (although recent evidence suggests that ozone and other factors may well be involved). In fact, under an ordinance recently promulgated by the Federal Government, strict new controls have now been introduced on emissions from "large-scale firing installations". Broadly speaking these will require that all large installations (above 300 megawatt thermal) that have the necessary remaining service life are retrofitted with flue gas desulphurisation within five years. The same standards will apply to smaller installations by 1993.

8. A major event in relation to the problem of long-range transboundary air pollution was the first meeting of the Executive Body of the Convention which was held in June this year. The meeting was inevitably much concerned with procedural matters and with reaching agreement on the continuation of the work programme which had previously operated on an interim basis. Proposals, which Britain has consistently supported, for careful study of costs and benefits of control action were unanimously agreed. The main policy discussion centred around proposals put forward by the Nordic countries, and by West Germany, Switzerland and Austria, that signatories to the Convention should commit themselves to a 30% reduction in sulphur dioxide emissions by 1993, based on 1980 levels. This specific commitment was not accepted but the record of the meeting refers to recognition by the Executive Body of the need "to decrease effectively the total annual emissions of sulphur compounds, or of their transboundary fluxes, by 1993."

9. I hope that these brief remarks will convey an impression of the somewhat hectic pace of international developments concerned with acid rain over the last year or so. It might indeed be questioned whether the pace has been too great; there is a limit to the number of initiatives that can sensibly be handled at one time. During this period the dominant issue has been the acute German concern with the problem of forest damage, which has added greatly to the sense of urgency surrounding the acid rain problem. Indeed, this concern was great enough for the subject to be considered at meetings of the European Council held in March and June, at which the Heads of State endorsed the need for urgent action to deal with the danger threatening European forest areas. However, over the same period there have been significant developments in understanding of the causes of forest damage. Although much has still to be learned, the link between this damage and acid precipitation attributable to long-range transport of pollutants appears increasingly suspect. A recent scientific discussion convened by the Royal Society, which brought together many international experts, satisfied most of those present that many factors are involved. There is a strong link between the observed damage and the altitude and exposure of forests. Air pollution certainly appears to be a factor and sulphur dioxide and ozone appear particularly to be implicated, but 'acid rain' in the proper sense of the words is certainly not the sole cause. High ambient levels of sulphur dioxide are encountered in some areas due primarily to local industrial emissions. High ozone levels can arise in other areas as a result of photochemical action on emissions of oxides of nitrogen and hydrocarbons both from stationary sources and from vehicles. Both can interact with altitude, exposure and other stresses to damage plants. Slow changes in the soil, partly ascribed to deposited pollutants, may be more important than direct impacts.

10. Generally, research over the past few years has, therefore, led to significant changes in our perception of the 'acid rain' problem. Many, though not all, scientists accept that acid precipitation - again

operating largely through the soils of the affected catchments - is an important factor in the acidification of freshwaters in certain sensitive areas, and that this acidification has led to fish losses. But in various ways the picture has become more complex. The extent to which natural soil acidification processes may be involved is not yet clear but there is evidence that this could be a major factor: it is certainly true that many vegetation types and freshwaters are naturally acid just as rain itself is. It is known that land use practices, farming methods and forestry can contribute to increased acidity. There is need for a clearer understanding of the acidification process; the rate and scale of this process may depend crucially on ozone and other oxidants, which could have major implications for control strategy.

11. On the question of damage due to acid precipitation within the UK the picture is problematical. At DOE request, the acidity of rainfall in the UK has been investigated by the Acid Rain Review Group, whose preliminary report was published in June, 1982; the Group's final report is expected to be published in December 1983. This work has shown that in certain areas of the UK (parts of Cumbria and Scotland) the acid input is of the same order as in the high input areas of Scandinavia and North America. There are indications of increases in acidity in some inland waters and of decline in fish populations. Some of these changes began over a century ago and may be ascribed to the impact of the industrial revolution. There is considerable uncertainty about the extent of any effects on crops, vegetation or forests. In any event, it is now clear that any such effects will need to be evaluated in relation to atmospheric pollution as a whole rather than simply 'acid rain'; at the recent Royal Society discussion it was urged that the latter term be abandoned as dangerously misleading.

12. I turn now to the UK position in relation to the pressures on the control of emissions that I described earlier. It is useful first to look briefly at the UK

position on sulphur emissions in comparison with that of other European countries. It is well known that our emissions have decreased substantially in recent years; since 1970 the decrease amounts to nearly 30%. What is perhaps less generally realised is that over this same period emissions from the rest of Europe (excluding the UK) have increased by nearly 40%. Most of this increase is attributable to East European countries; in the West there have generally been decreases in emissions although in a few countries small increases have occurred. UK emissions are now below what they were in 1950 and indeed, in 1982, fell below the 1940 level. I think it is true to say that in no other European country is this position anywhere near to being reached. In Europe, excluding the UK, emissions have in fact nearly trebled since 1950; in West Germany, for example, present emissions are about 50% above the 1950 level although they are now falling. The remarkable decrease in UK emissions of course reflects many factors (notably use of North Sea gas) and cannot in the main be ascribed to deliberate control action. However, the decrease is nonetheless real. The head of the UK delegation to the first meeting of the Executive Body for the ECE Convention made clear that the UK did not intend to allow the downward trend in its emissions to be reversed.

13. The major question that arises is whether controls should be introduced to achieve further reductions in emissions. The question is usually posed in relation to sulphur emissions, especially power stations and the possible requirement for flue gas desulphurisation. However, it should not be forgotten that nitrogen oxide emissions are also involved both directly (it is estimated that nitric acid contributes about 30% to acidity in the UK) and indirectly, with hydrocarbons, as precursors to ozone produced by photochemical action. In the UK about 25% of nitrogen oxide emissions and 40% of hydrocarbon emissions come from vehicles. Potentially, the question of controls goes a good deal wider than the flue gas desulphurisation issue and it is noteworthy that the German Government has announced that action to curb vehicle emissions forms an important element in its over-

all strategy.

14. A rational approach to the question of controls must seek to weigh the costs and benefits. There are various possible paths towards a reduction in sulphur emissions and the optimum strategy to achieve a given overall reduction would require a good deal of study. However, the costs would certainly be high. To achieve a 30% reduction for the UK, if this were to be done by flue gas desulphurisation applied to power station emissions alone, would cost well over £1 billion capital and would lead to total annual costs of about £250 million, corresponding to an increase of 4 to 5% in the price of electricity. There would be other environmental costs arising from the need to quarry and transport the very large quantities of limestone required in the desulphurising process, and to dispose of the resulting wastes.

15. On the other side of the coin the picture is far less clear. I have referred already to the considerable uncertainties that still exist about the connection between sulphur (or nitrogen oxide) emissions and adverse environmental effects attributable to long range transport of pollutants. The uncertainties that exist about whether any such effects would be significantly ameliorated by even a substantial reduction in emissions are no less great. In this context I would draw attention to the recent public statement about 'acid rain' made by the National Society for Clean Air. We in DOE would generally agree with the Society's analysis of present knowledge on the effects of 'acid rain'. I note in particular the reference to the fact that in spite of variations in emission rates that have occurred over time, there have been no substantial changes in the average measured acidity or sulphate content of rainfall in Europe at least since 1965. This may be a reflection of a factor that we are only now beginning to appreciate, that is, the long timescales that may apply to acidification phenomena. It is clear that some changes, for example in freshwater catchments and forest soils, have been taking place over many

decades, if not centuries, and are unlikely to be rapidly reversible.

16. In its statement the Society points to its commitment to the cause of clean air and to its role in urging responsible action by Government on behalf of the environment. In the light of that commitment the Society recommends that signatories to the Convention should agree to a target percentage reduction in national emissions by a specified date. But, for the reasons outlined above, the direction that responsible action should take is by no means obvious. We just do not know what the key factors are in this complicated problem. The Government's view is that scientific understanding of the 'acid rain' problem in all its various aspects is as yet insufficient to provide a clear basis for commitment to a very costly programme of emission reduction, and that the most responsible action at present is to press forward with research.

17. The great political activity on the 'acid rain' question over the last year has been matched by activity in the scientific field. One index of scientific concern is the remarkable number of conferences and seminars that have been held on this subject. To mention only the most recent of these, both held in September, there was the Royal Society discussion meeting on the ecological effects of deposited sulphur and nitrogen compounds to which I have already referred; and the symposium on "Acid deposition - a challenge to Europe" organised by the European Commission in Karlsruhe in West Germany. Such meetings serve to bring into focus the research work that is proceeding in many countries on the acidification problem.

18. In the UK the commitment to research is considerable. DOE sponsored research on 'acid rain', covering work on both effects and atmospheric chemistry, will amount to about £600K in the present financial year, and it is hoped that this programme can be substantially expanded in 1984/85. Other government agencies, in particular the Natural Environment Research Council, are supporting

research that is relevant to the 'acid rain' problem to the extent of about £0.25m a year, and again there are plans for a considerable increase in this activity in 1984/85. In addition, the CEGB, through its Central Electricity Research Laboratories, has for many years supported a large programme of 'acid rain' research which is currently running at about £1m a year. Of course, the CEGB is seen as a major polluter and there is a tendency to regard its research in this field as suspect. Such an accusation cannot be levelled at the new programme of research, jointly supported by the Board and the National Coal Board to the extent of £5m over five years, which has recently been announced. The impartiality of this collaborative programme, which is to investigate the causes of acidification of surface waters in affected areas of Norway and Sweden, is guaranteed by the fact that its direction is entirely in the hands of the Royal Society, the Norwegian Academy of Science and the Royal Swedish Academy of Sciences. The scale of this research effort is a measure of our national concern with the 'acid rain' problem and of the importance attached to increased understanding as a basis for decisions on emission controls. The research I have so far referred to is concerned with the effects of acid deposition and with the processes of atmospheric chemistry involved. Consideration is also being given to the support of new research on the technology of emission control, having as its aim the development of less costly techniques. It is perhaps worth noting that if manifestly cost effective measures were now available they would already be a requirement within the 'best practicable means' formula that applies to the control of emissions from major combustion sources.

19. The pace of scientific advance is of course unpredictable but there can be little doubt that acid rain will continue to be a subject of great international concern for the foreseeable future. Certainly the international developments that I have described, under the UN/ECE Convention and within the European Community, will continue. I would end by stressing the importance that we attach to the Convention. Long range trans-

boundary air pollution is by its nature an international problem; if action is to be taken to reduce emissions it must be taken by all the countries concerned - Eastern as well as Western - on an agreed basis. The basis of UK policy on acid rain is to continue to work with other concerned countries through the Convention to achieve agreed solutions to this complex problem.

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DEVELOPMENTS IN THE MEASUREMENT AND CONTROL OF PROCESS ODOURS

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1. INTRODUCTION

During the 1960s local authorities in the United Kingdom were receiving an increasing number of complaints about the nuisance caused by malodorous processes and operations. In 1971, the Department of the Environment set up a Working Party, which reported in 1973 on the nature and magnitude of the problem and in 1975 described best present practice in odour prevention and abatement[1]. The Working Party also recommended further research and a substantial programme was carried out at Warren Spring Laboratory between 1975 and 1978, financed by DoE, with participation by 22 firms and trade associations and 84 local authorities. The results contained in over 30 research reports were published in 1979 as a series of seven summary reports and subsequently (1980) this experience was used to prepare the publication, 'Odour Control - A Concise Guide'[2].

Since then research into the measurement and control of process odours has continued at WSL, albeit at a lower level, up until the present. So it is with respect to the timescale indicated above that developments will be reviewed. Although the results discussed will be mostly drawn from WSL research and practical experience it should not be overlooked that there is now an extensive world-wide literature on odour measurement and control. However, because WSL was able to adopt from the outset a reliable system for odour strength measurements, it is convenient to use WSL results to provide examples of odour reduction by various techniques.

2. ODOUR SOURCES AND COMPLAINTS

The 1973 survey found a total of 1,772 odour sources which had been notified to local authorities in the United Kingdom. These sources could be broadly classified into agriculture (37%), animal by-products rendering (22%), all other manufacturing processes (34%), sewage treatment/sludge disposal etc (7%). Since that time, there has been some rationalization in the animal by-products industry and an increase in the size of livestock production units. In a more recent partial re-survey (1980) WSL analysed 814 odour sources reported by local authorities[3]. Although the survey probably under-represented rural areas, it tended to confirm the general impression of source reductions in agriculture (22%) and rendering (11%), whereas manufacturing processes (53%) and sewage treatment (14%), because their numbers have kept up, become a larger fraction of the total in 1980.

This broad classification conceals the great variety of processes and operations giving rise to complaints about odour nuisance and about 90 categories were needed to classify them in the 1980 survey. However, the 17 categories shown in Table 1 (left-hand column) accounted for 55% of the total number of odour sources. Some of the individual sources within each category, as marked with an asterisk, gave risk to large numbers of complaints but for any one type of source, the number of complaints varies greatly, reflecting the extent of odour control applied, the proximity of housing and other factors. For example, the range for rendering plants was 1-337 complaints over a two-year period and 4-100 for pig-rearing. In addition Table 1, right-hand column, shows individual odour sources which, although few in number, caused considerable public annoyance.

A general perspective on numbers of complaints can be gained from the results of another survey carried out by WSL in 1977/78[4] where 51 local authorities, with a factory in the area at which WSL had made odour strength measurements, provided information on complaints totalling 2,859 during a two-year period. About one-half (48%) of the reply forms reported up to 10 complaints; about one-third (35%) reported 10-100 complaints, while 17% reported from 100 to 800 complaints.

3. PROCESS ODOUR COMPOSITION

It is usual to describe the odour by the nature of the process causing it but process odours, especially where animal or vegetable matter is heated, are often complex mixtures in air of many substances present at very low concentrations. These substances may be individually malodorous and will occur with large numbers of other compounds including hydrocarbons which cause little or no odour response. Recent years have seen the development of techniques for the sampling and analysis of such mixtures containing perhaps only parts per million (ppm) or even parts per billion (ppb) quantities in air.

Analysis of the process odour is likely to involve pre-concentration on an adsorbent, e.g. Tenax-GC and then separation on a gas chromatographic column, followed by identification of the separated components. The most positive and comprehensive method of identification is a combined gas chromatograph-mass spectrometer, GC-MS, linked to a computer-based data system. If part of the flow of separated components is delivered to an 'odour port', then the odour, if any, of each component can be described. Figure 1 shows an analysis of rendering plant odour, taken after a condenser had removed ammonia and organic acids. The malodorous compounds include hydrogen sulphide; organic sulphur compounds, e.g. methyl mercaptan, dimethyl disulphide; amines, e.g. trimethylamine; aldehydes, e.g. butanal[5]. In a recent analysis of rendering plant odour, 110 volatile compounds were detected, of which 26 were malodorous[6]. Such information on the composition of process odours is likely to become increasingly useful in the design of abatement equipment.

The malodorous compounds may be present in very low concentrations but are nevertheless detected because of the sensitivity of the normal human nose, as illustrated by the following odour detection threshold values[7] expressed in parts per billion (10^9): hydrogen sulphide, 0.5; methyl mercaptan, 2; dimethyl disulphide, 1; trimethylamine, 0.2. So unless the concentrations of the malodorous compounds emitted from the factory are diluted by the atmosphere to lower concentrations than these threshold values before they reach the surrounding community, then complaints about odour nuisance are possible.

4. ODOUR PROPERTIES AND EFFECTS

Annoyance seems to be the most frequently cited response because of an impairment of the amenities of house and garden, or an unpleasant working atmosphere due to emissions from a nearby factory or farm. It is now appreciated that annoyance is the combined result of a number of odour properties[8].

Odour intensity is the strength of the perceived odour sensation and depends in a complex way on the concentration of the odorous substances present. It can be measured by comparison with reference samples but often an alternative measure of odour strength, the dilution to threshold value, is determined as described in the next section.

Odour character is the property that enables us to distinguish between different odours and it is said that an odour with a distinct recognisable character tends to be more annoying. It also, of course, enables us to identify the odour and perhaps associate it with some process or operation which we dislike for other reasons.

Hedonic tone is the term used to place an odour on a scale of pleasantness and unpleasantness in a neutral context and differs from acceptability which is a judgement made in the context of a specific situation, e.g. a pleasant odour from a fragrance factory may be unacceptable if persistent in a residential area.

Frequency of process odour releases and the duration of such occurrences are also significant factors in determining nuisance.

The resulting complaints may lead to abatement notices and legal action. The economic consequences of process odours may include effects on residential property values, refusal of planning permission for factory extensions, the cost of improvements at the factory and the cost of installating and operating odour control equipment.

Another group of effects concerns adverse reactions causing physical symptoms, e.g. headaches, nausea. Such reports are mostly self-reports rather than objective measurements. Nevertheless studies have shown the immediacy of the response following exposure to the process odour and it is probably not correct to classify all community reactions as annoyance reactions. There is also the question of long-term exposure to process odours which, as shown, may well be complex mixtures of many compounds, albeit at very low concentrations, some of which are malodorous. So far, most process odours have not been analysed in sufficient detail to know what might be the typical composition and the quantitative variation for a particular named process.

5. SENSORY MEASUREMENTS

In recent years, increasing use has been made of odour strength measurements, determined as dilution to threshold values, D. Samples of the odorous air are diluted with odour-free air until the observers (panellists) cannot detect any odour. The dilution to threshold value might be taken as the dilution, D, required to obtain a negative response from 50% of the panellists. Various forms of olfactometer[8] have been developed for presenting a continuously diluted sample to the panellists ('dynamic dilution'). Such instruments include the Scentometer (used originally for ambient air measurements), the Misco and the Mannebeck (mask-types), the Hemeon (a high flow-rate device with sniffing ports) and the Dynamic Triangle olfactometer (designed for the forced-choice method).

The WSL transportable dynamic dilution olfactometer[4], illustrated in Fig. 2, is also a high flowrate instrument (190 litres min^{-1} from each sniffing port) and covers the dilution range 75-750,000. The samples of odorous process air are collected in large bags fabricated from polyvinyl fluoride film. In a new development, involving larger samples and a modified WSL olfactometer, ambient odours with D-values as low as 5 can be measured. The various forms of olfactometer in current use produce different numerical values due to differences in flowrate, sample presentation and other factors but, in general, the detection thresholds can be related by comparison plots. Table 2 records examples of WSL measurements on various unabated process emissions[4].

Odour strength measurements have a number of practical uses. Measurements in the ambient air can be used to locate odour sources and to study their distribution in the community. The different operations in a factory can be investigated to determine which contribute most to the total odour emission rate with a view to possible process changes. Where abatement equipment has been installed, measurements of odour strength on inlet and outlet samples show the efficiency of odour removal. A knowledge of the dilution to threshold value, D, together with the volume flow rate, F, can also be used to estimate the maximum distance over which the process emission is likely to cause complaints and hence to indicate the removal efficiency required from abatement equipment.

An empirical analysis[4] of odour complaints in relation to the odour emission rate, E, (D x F) suggested that the maximum distance, d_{max} (metres) from an odour source at which complaints are likely to arise is given by:

$$d_{max} = (2.2\ DF)^{0.6} = (2.2\ E)^{0.6}$$

where odour strengths are measured by a WSL-type olfactometer. (The uncertainty of this equation is given by the range $(0.7E)^{0.6} - (7E)^{0.6}$ and also the result will be invalid unless d_{max} is at least 40 times the effective chimney height and D is greater than 500.) If D = 20,000 and $F = 12.5\ m^3\ s^{-1}$, then d_{max} would be 2800 metres; reducing D to 2000 at the same flowrate would reduce d_{max} to 700 metres.

6. GENERAL CONTROL METHODS

There are essentially four ways in which the nuisance caused by process odours can be minimised or eliminated:

(i) Process and Plant Changes taken to mean not only changes in operating parameters but also improved facilities and procedures for the storage and handling of raw materials, products and waste. Better buildings may encourage good housekeeping and should confine the process air so that it does not escape to the surrounding community before any treatment required. Plant in the open may require special attention to eliminate potential leakage points by better maintenance or re-design. Where bio-degradable material is being stored in the open in heaps or lagoons or spread on the land, the practices involved may need to be reviewed.

(ii) Dilution by the Atmosphere so that the concentrations of the malodorous compounds in the process emission are reduced below their detection thresholds is, in principle, another method of avoiding community complaints. This may be achieved by siting a new plant well away from housing etc. but future housing developments may nullify the initial benefit of an isolated site. Alternatively, sufficient atmospheric dilution may sometimes be achieved by discharging the untreated process gases through a stack of suitable height. (Of course, the variability of meteorological conditions is such that stack dispersion alone is not a totally dependable method for avoiding all complaints.) Steps taken to minimise the volume flowrate, F, and strength of the odorous emission, D, by the process and plant changes indicated in (i) above will reduce the height of the stack required.

The first step is to calculate the required stack height in the absence of any abatement equipment; the calculation will be complicated by the presence of other buildings and local topography. In practice, this height could well prove excessive (either visually or in cost terms) and then the target efficiency for abatement equipment must be calculated so that discharge at an acceptable height is only required as the final stage of odour control. Table 3 shows stack heights considered to be adequate for dispersing process odours with the illustrative odour strengths, D = 2000 and D = 20,000 for a range of volume flowrates[9]. (Calculations were based on the range of atmospheric stabilities and associated wind speeds encountered in the United Kingdom and on the assumptions that the nuisance threshold is 5 times the odour detection threshold and that the maximum detectable concentration in a 3-minute period is 10 times the 3-minute average.) Table 3 indicates the need for odour prevention or treatment so as to reduce odour strengths and the need to minimise odour volumes, if a stack of acceptable height is to be built. Reference back to the D-values for unabated odours in Table 2 shows that, in many cases, treatment to reduce the odour strength to D = 2000 (possibly often the practicable and economic minimum) will require very high odour removal efficiencies, e.g. 90% or more.

(iii) Odour Modification involves the addition of other chemicals which modify our response to the process odour because of changes in the perceived odour intensity (counteraction) or the perceived odour quality (masking). They are well known for indoor applications where they are dispersed as aerosol sprays, or evaporated from wick- or gel-type dispensers. For process odour control, the odour modifier may be sprayed into stack emissions; if incorporated into the process, the modifier must be capable of withstanding the process conditions. The selection of odour modifiers and the dispensing rate would seem to be critical and the modifier should never prevent the perception of toxic or harmful substances. The nature of the method makes it difficult to measure the degree of nuisance abatement achieved and, although some successful applications have been reported, its status for process odour problems remains unclear.

(iv) Treatment of the process gases before discharge by one or more abatement techniques is often necessary. Such techniques include thermal or catalytic incineration, absorption in chemical reagent solutions, adsorption on carbon and biological oxidation. Research activity in recent years has been concerned with improving these techniques with respect to efficiency and cost and examining how they may best be applied to specific process odour problems. Some of these developments in odour treatment are reviewed in Sections 6-9.

7. INCINERATION

It is well known that effective odour control can usually be achieved by raising the process emission to a sufficiently high temperature for an appropriate length of time to oxidise the malodorous compounds present to carbon dioxide, and water, plus small amounts of the oxides of sulphur and nitrogen which have little odour. The design of thermal afterburners has been the subject of extensive study[10] and it is now better appreciated that odour destruction requires considerable temperatures, typically 650-800°C, good mixing (in, say, 0.3-0.5 s) to ensure that all the process gases reach the required temperature and then adequate time to allow completion of the oxidation reactions (say, 0.1-0.3 s). Specific temperatures and residence times have been designated by some statutory bodies, e.g. some US states require animal rendering emissions to be incinerated at 650°C for at least 0.3 seconds.

Table 4 records the satisfactory performance of some thermal afterburners evaluated by sensory measurements but also demonstrates the importance of an adequate temperature[11]. For example, when treating the uncondensed gases from chicken litter drying, odour removal efficiency fell away as the temperature was lowered to 660°C. Treating the emission from web offset printing at the lower temperature, 520°C, actually increased the odour strength, presumably due to the formation of more odorous partial oxidation products. In the WSL survey in 1980[3], it was reported that thermal incineration was also successful in treating the odours from meat processing, food flavour manufacture, instant coffee production (plus dispersion), paint spraying and stoving, core-baking, phenolic resins for electrical insulation and roofing felt manufacture; mercaptan odour from an oil-refinery was considerably reduced.

A major disadvantage when treating large volumes (often containing little combustible material) is the cost of fuel which has increased substantially during the period under review and three approaches have been adopted to lower operating costs: heat recovery, the use of an existing boiler (or kiln) or the incorporation of a catalyst. In practice, feeding the malodorous air stream to an existing boiler, even when the required temperature is apparently achieved, may be unsatisfactory because of poor mixing, insufficient residence time, corrosion etc. However, with careful design some excellent performances have been achieved without detracting from the efficiency of the boiler e.g. tar processing, 99% odour removal at 900°C; feather meal drying, 96-98% removal at 600°C[11]. Boiler incineration as used in fish meal production for odour control has been specially investigated[12].

Catalytic incineration may provide effective odour control at 350-400°C, thereby saving perhaps 40-60% on fuel costs compared with thermal incineration, but partly offset by higher capital and catalyst replacement costs. Catalytic incineration is unsuitable for process emissions containing catalyst poisons which cannot be economically removed or where the catalyst surface is liable to become blocked with particulates or polymeric material. Various types of catalyst can be used[13] including a major innovation of recent years where the active component – a very small amount of platinum group metal – is dispersed in a thin layer of alumina supported on a ceramic honeycomb. A compressed metal ribbon catalyst is also used where the active component is electrodeposited on to a crimped nichrome ribbon compressed into a mat. Table 5 shows examples of the efficiency of such catalysts for controlling the odours arising from the cooking of animal by-products[14]. The platinum-honeycomb catalyst in the first example was tested after three years of continuous operation; the improvement in performance at 400°C compared with 350°C is evident. In similar tests, but probably involving a shorter period of contact with the process gas, a platinum-honeycomb catalyst was 84-88% efficient.

8. ABSORPTION IN REAGENT SOLUTIONS

Transfer of the malodorous compounds from the process air stream to the liquid phase is often the best method for treating large air flows (say, more than 2 $m^3 s^{-1}$) using, for example, an absorption tower. Water is the usual liquid but commonly a chemical reagent is added to increase the transfer efficiency and the capacity of the liquid phase. Preliminary treatment may involve condensation where the process emission is hot and steam-laden; scrubbers, cyclones etc may be used to remove particulates. The types of absorption equipment most readily designed for the performance required in process odour control are known, e.g. the counter-current packed tower can be an effective means of contacting the process odour and the reagent solution. The complexity of many process emissions such as those arising from the heat treatment of animal or vegetable matter, means that in practice a number of separate absorption stages with different reagents may be required. The specification of suitable chemical reagents for each particular application remains a problem.

For the control of rendering odour, multiple stages of alkaline hypochlorite achieved 93% odour removal (standard deviation, 3%) during a week-long test[15] but it was concluded that the problem had not been completely solved because hypochlorite will not remove all the odorants. In another system for high-intensity odours[16] a venturi using a solution of trisodium phosphate, pH 8, a packed tower with phosphoric acid, pH 3, and a packed tower with sodium hypochlorite and sodium hydroxide, pH 10, achieved about 96% odour removal under best operating conditions. An extensive study of reagents for absorbing rendering plant odours has also been made by WSL[17]. In general, a three-column combination of acidic hypochlorite, sodium hydrogen sulphite and sodium hydroxide gave the best results (Table 6) in field-tests.

In our survey[3], absorption in a suitable reagent solution was the most frequently reported method for treating odours arising from chemicals and plastics manufacture. This method was considered to be successful in controlling odour from the production of antibiotics, fatty acids, tanning chemicals, dye-stuffs, amines, phenolic compounds, methyl methacrylate and during protein hydrolysis. Odour removal efficiencies are unknown, but probably were sometimes lower and generally more variable than those observed in the tests described above.

9. ADSORPTION ON ACTIVATED CARBON

The principle involved is the removal of the malodorous compounds by adsorption on the carbon as the air being treated passes through the carbon bed. The use of activated carbon for solvent recovery is well known and it is also the basis of many indoor systems, e.g. to treat domestic and restaurant kitchen odours. In treating process odours, activated carbon may be the primary abatement method, or placed after other abatement equipment to improve overall efficiency.

The performance of activated carbon for odour removal depends strongly on establishing correct operating conditions[18]. The upper temperature limit preferred is as low as 30-40°C; above 75% relative humidity efficiency is reduced, except for some water soluble odorants, and hence precooling (and also filtration of dust particles) may be necessary. Smaller grain size improves adsorption efficiency but causes a higher pressure drop and fan power consumption. The linear velocity and contact time may be changed (to treat a volume flowrate pre-determined by process or ventilation conditions) by changing the bed depth and area. Carbon beds have a finite service life before odour break-through occurs. Thin beds, say, a few centimetres deep, with the advantage of low resistance to air flow, may be used if odorant concentrations are small and are often discarded and replaced rather than regenerated. Deeper carbon beds, say 0.3-1.8 m, as used in solvent recovery systems, provide a much larger adsorbing capacity and may be regenerated. In operation, channelling (or by-passing at the walls) may arise from irregular packing, or attrition of the carbon granules, thereby reducing odour removal efficiency.

For the treatment of process odours (as distinct from solvent recovery or air-conditioning applications) measured odour removal efficiencies were low for various installations[19]. The specific reasons were not determined but consideration of the performance parameters outlined above indicates that efficiency is critically dependent on good design and correct operation with replacement or regeneration of the carbon bed at appropriate intervals.

10. BIOLOGICAL TREATMENT

Biological towers are similar in principle to packed absorbers except that odour removal is achieved by the use of micro-organisms grown on an inert packing rather than by chemical reagent solutions sprayed over the packing. The biological tower may be started up with a mixture of activated sewage sludge and nutrient solutions. Recently, however, there seems to be more interest in an alternative form of biological treatment where the odorous air is passed through a bed of soil, peat or compost. The mechanism of odour removal is believed to involve the dissolution of the odorants and oxygen in water followed by their reaction under the influence of enzymes, generated by, or forming part of, the micro-organisms. Therefore odour abatement would be facilitated by a large gas-liquid interface and sufficient microbial activity, conditions which may be provided in either a bed of soil, peat etc, or in a packed tower.

WSL has a demonstration soil bed at a maggot farm, deodorizing the ventilation air by passing it through a system of perforated pipes buried after excavation under a layer of gravel and then loam to a depth of one metre. It also appears that 'compost filters' are widely used on animal production units in Bavaria and the preferred filter material is a mixture of fibrous peat and heather or brushwood based on minimising back pressure and hence fan power consumption[20]. The open structure allows adequate drainage after heavy rain which would otherwise increase the back pressure. Conversely bio-filter moisture levels must be maintained or microbial action will be inhibited and also channelling may develop.

Humidification of the process air, if necessary, may be better than a sprinkler system and may be incorporated as water-washing for dust removal and cooling.

11. FUTURE DEVELOPMENTS

It is becoming better appreciated that process odours are often complex mixtures of many substances at extremely low levels in the discharged air, together with many other substances with little or no odour. Analytical methods will continue to develop for the identification and quantitative determination of the malodorants present. This will enable the problem to be specified in terms of the concentrations of known substances to be removed whereas, at present, the odour is described by the name of the process. There is a tendency to assume that the odour named always has the same composition and should be abated in the same way whereas the processing conditions adopted may change the composition from plant to plant. Also the location of the plant with respect to housing and other occupied buildings is a major consideration in determining a target efficiency for the abatement equipment. Hence it will become accepted that the individual nature of each problem must be respected within the concensus of opinion as to how that type of process odour should be controlled.

Sensory measurement, e.g. dynamic dilution olfactometry, is becoming more acceptable as an essential element in the investigation of any process odour problem. The measurement of other process odour properties might also be routinely determined in the future and more work done to relate these properties to the impact of process odours on the community. However, the response aroused when a pervasive odour is identified with an objectionable source, or the feeling that the odour may be due to harmful substances, is not readily quantified. Obviously it would be preferable if the potential malodorants did not exceed their detection threshold concentrations in the community.

It is to be hoped that in the future, process technology will be developed to minimise the generation of malodours and that new buildings will be designed to prevent the escape of untreated process odours to the community, if likely to cause a nuisance. Where required, odour control equipment will be specified and integrated into the design of the complete plant. It seems likely that future R & D will concentrate on economical abatement methods; for example, on methods with the lowest energy costs. Absorption in reagent solutions tends to have favourable operating costs and more will be discovered about the selection of suitable reagents for treating specific problems. Adsorption, e.g. on activated carbon, tends to have favourable initial capital costs and systems will be developed to reduce adsorbent replacement costs. Finally the installation and running costs for biological treatment (bio-filters) seem very favourable and it is likely to be used increasingly for some odour problems as confidence in its efficiency becomes established.

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TABLE 1. - Some UK Processes and Operations Causing Odour Complaints

	Most Common Sources (in order of frequency)	Individual Sources Causing Many Complaints (additional to sources marked*)
1	Manure spreading*	Brewing
2	Sewage treatment*	Brick-making
3	Animal rendering*	Canning (food)
4	Foundry operations*	Carpet-backing
5	Paint spraying	Chocolate manufacture
6	Sewage sludge disposal*	Dyeing, stentoring
7	Commercial kitchens	Fish storage
8	Poultry rearing	Herbicide/insecticide manuf.
9	Pig rearing*	Maize processing
10	Tanning, fell-mongering*	Malt roasting
11	Organic chemicals manufacture	Paper coating
12	Domestic/industrial refuse*	Printing
13	Abattoir waste storage	Printing ink manuf.
14	Maggot breeding*	Tin-plate coating
15	Dry-cleaning	Tar distilling
16	Waste incinerations	Sugar beet processing
17	Paint stoving	Viscose manufacture

TABLE 2. - Examples of Process Odour Emissions Before Abatement

Example	Odour Strength, D	Volume Flowrate, F (m^3 s^{-1})	Odour Emission Rate, D x F (m^3 s^{-1})
Chicken house (15,000 birds)	600	4.2	2,520
Maggot farm (3,000 gal/wk)	5,000	6	30,000
Nylon stentoring	18,000	2	36,000
Printing (web-offset)	40,000	1.5	60,000
Potato crisps (100,000 t/yr)	30,000	14.5	435,000
Fermenter sterilizing	715,000	0.75	536,000
Animal rendering (350 t/wk)			
ventilation air	6,000	13.5	756,000
process air	1,350,000	0.5	
Fishmeal			
white fish	150,000	7.9	1,185,000
80% oily fish	400,000	7.9	3,160,000

TABLE 3. - Stack Heights for Adequate Dispersion of Process Odours

Odour Strength, D	Volume Flowrate, F ($m^3 s^{-1}$)	Odour Emission Rate, D x F ($m^3 s^{-1}$)	Required Heights (metres)	
			Effective	Actual*
2000	1.0	2,000	14	16‡
	2.5	5,000	22	20‡
	5.0	10,000	32	25
	12.5	25,000	50	39
	25.0	50,000	71	55
20,000	12.5	250,000	158	147
	25.0	500,000	224	208

* Assuming efflux velocity of gases at stack top = 15 $m\ s^{-1}$ and wind speed = 4 $m\ s^{-1}$.

‡ Corrected assuming building height 10 m, width 30 m and length 50 m.

TABLE 4. - Performance of Industrial Thermal Afterburners

Source of Odour	Operating Temperature (°C)	Dilutions to Threshold		Reduction in Odour Strength (%)
		Inlet	Outlet	
Chicken litter drying,	715	193,300	7,800	96
uncondensed gases[a]	690	128,000	6,100	95
	660	206,000	76,300	63
Web offset printing[b]	700	11,900	1,200	90
	520	10,100	23,600	increased
Rendering, uncondensed cooker gases[c]	600	525,000	4,000	99
Malt roasting	600	2,800,000	230,000	92

a, gas fired; b, gas fired 0.5 s residence time; c, oil fired 0.3 s residence time

TABLE 5. - Performance of Industrial Catalytic Incinerators Treating Rendering Plant Process Gases

Catalyst Type	Operating Temperature (°C)	Volume Flowrate ($N\ m^3\ h^{-1}$)	Dilution to Threshold		Reduction in Odour Strength (%)
			Inlet	Outlet	
Pt honeycomb	400	1700*	800,000	45,000	94
			1,180,000	7,000	99
			1,350,000	20,500	98
	350	1700*	210,000	27,000	87
Pt ribbon	400	1700	690,000	22,000	97
			970,000	46,800	95

* Corresponding to a space velocity (volume flow of gas per hour/catalyst volume) of 30,000 h^{-1}.

TABLE 6. - Field Tests of Multi-Stage Absorption at 3 UK Rendering Plants

Odour Source	Dilutions to Threshold		Reduction in Odour Strength (%)
	Inlet	Outlet	
Drying process gases	29,000	1,200	96
Hot pressing process gases	93,000	780	99
Mixed process + ventilation	224,000	2,200	99

Stage 1, sodium hypochlorite 0.8-1.05 g/litre, pH 3.5-4.5;

Stage 2, sodium hydrogen sulphite, 5 g/litre;

Stage 3, sodium hydroxide, 4 g/litre.

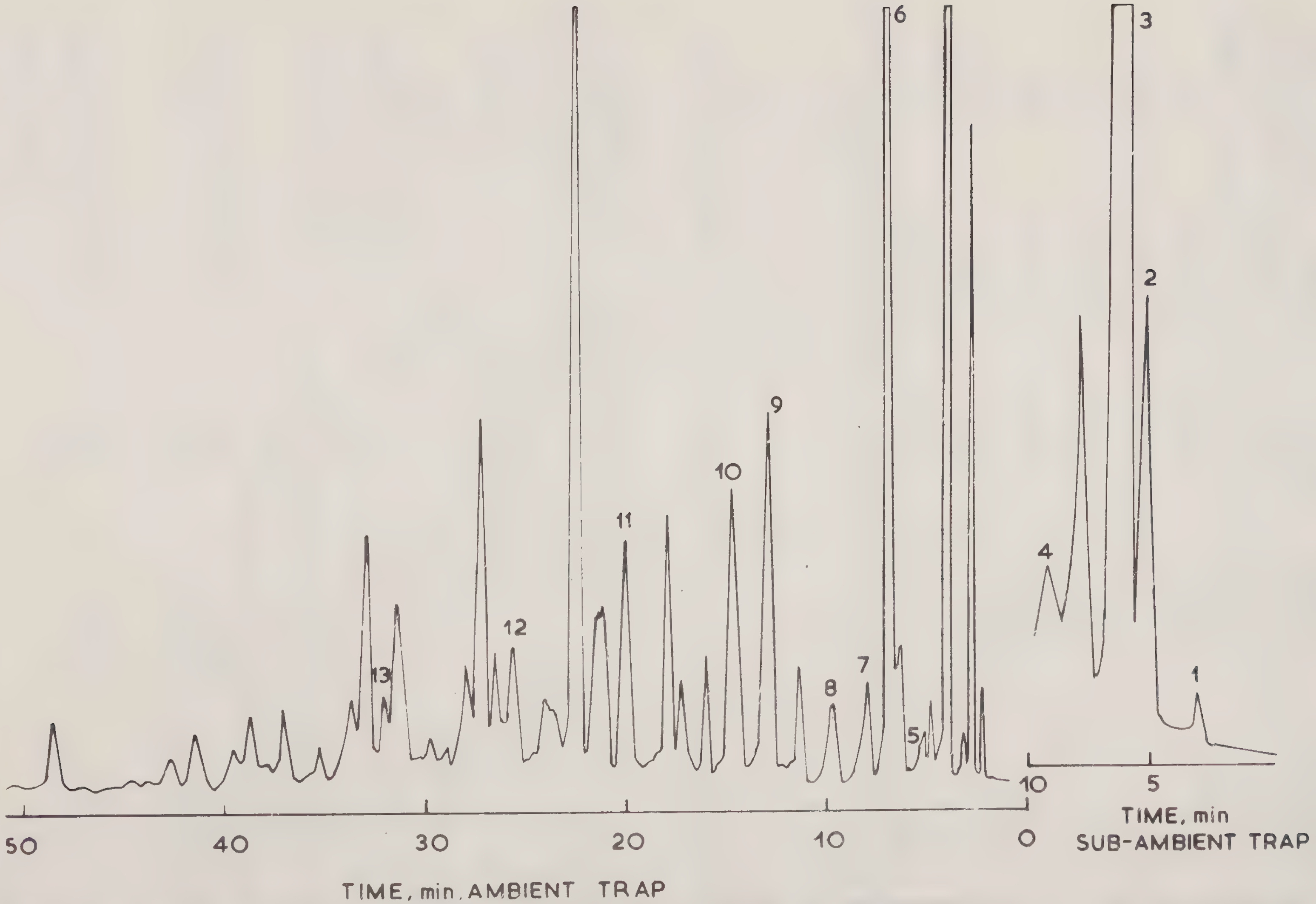

Fig. 1 Analysis of animal rendering odour (after a condenser). Malodorants identified include: (1) hydrogen sulphide; (2) ethanol; (3) methyl mercaptan; (4) trimethylamine; (5) butanal; (6) methyl butanol; (7) benzene; (8) pentanal; (9) toluene; (10) dimethyl disulphide; (11) heptanal; (12) octanal + 2-*n*-propyl thiophene; (13) dimethyl trisulphide.

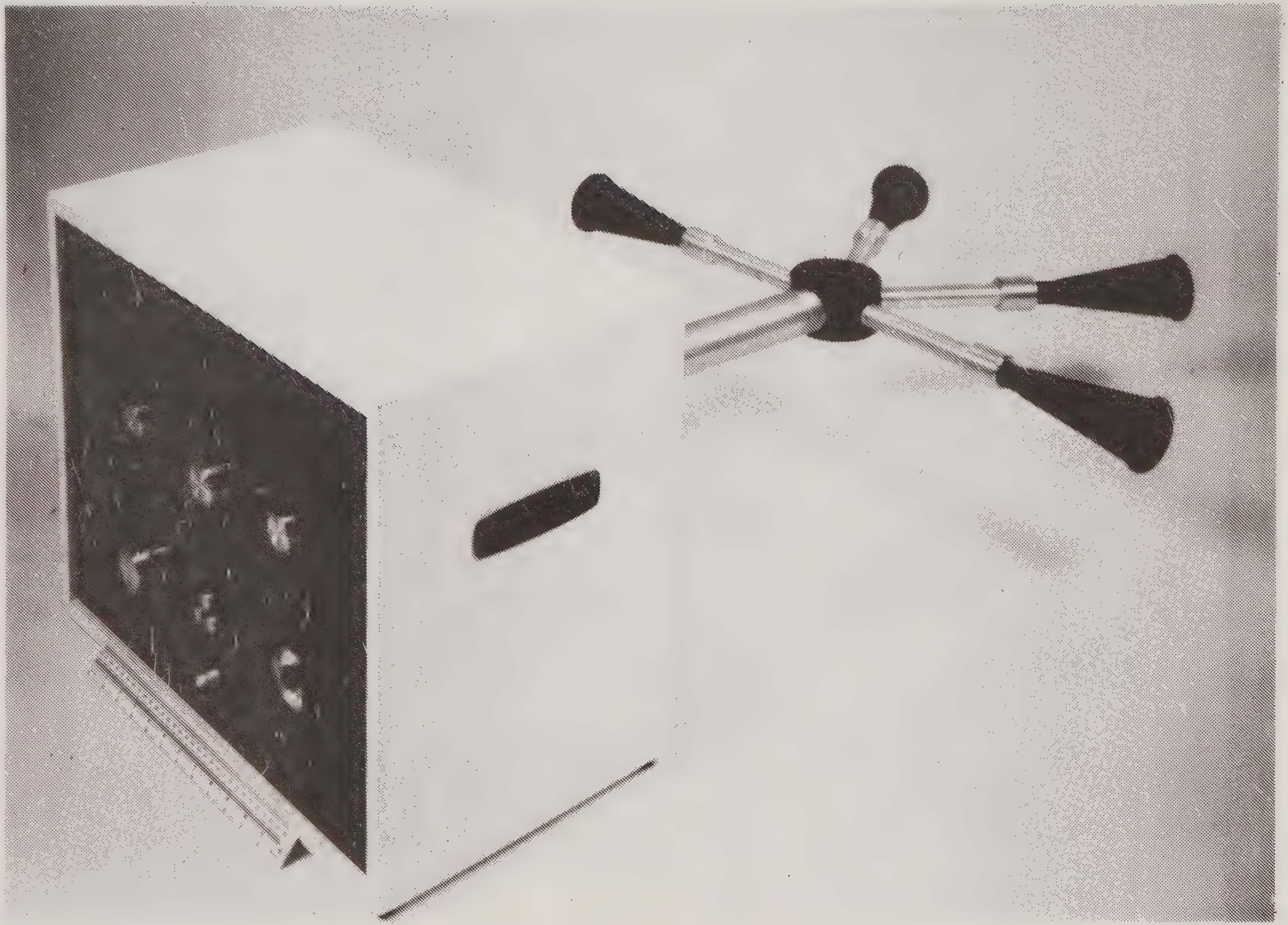

Fig. 2 Warren Spring Laboratory (WSL) transportable dynamic dilution olfactometer.

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INSULATION OF BUILDINGS AGAINST EXTERNAL NOISE

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SUMMARY

Methods of increasing the insulation of buildings against external noise are discussed. It is concluded that, while an attenuation of 35 db(A) is readily obtainable in traditional constructions with double windows, a higher insulation will require detailed considerations of the whole building envelope. The associated problems of providing adequate ventilation for comfort and safety are considered. Some preliminary findings from a study of the acceptability of the insulation package installed under the Noise Insulation Regulations indicate that it is generally satisfactory.

INTRODUCTION

The first proposal that funds should be made available to enable dwellings to be insulated against external noise was made by the Committee on the Problem of Noise (Wilson Committee)(1). The Building Research Station described in an appendix to the report of the Wilson committee a possible method of protecting rooms against external noise. Three years after the report was published the first scheme was introduced to provide grants for improving the insulation of dwellings near Heathrow Airport against aircraft noise(2). Subsequently similar schemes have been introduced at other airports. Following an increase in concern about the problem of road traffic noise in the early seventies, a scheme was introduced(3) to insulate dwellings subjected to high levels of noise from new and modified roads. The specification for the insulation package was based on experience with the airports schemes and a pilot study undertaken by the BRE(4). The Noise Advisory Council in one of its final reports(5) pointed out that many dwellings and other noise sensitive buildings are subjected to excessively high levels of external noise but are not eligible for treatment under existing schemes. The report pointed out that although source noise levels for aircraft and road vehicles were being reduced it would be many years before overall reductions in noise were achieved. It is clear therefore that the use of increased external insulation will continue to play an important role in ensuring acceptable noise environments within buildings.

The problem of increasing the external insulation of buildings is closely linked with the problems of ensuring adequate ventilation for thermal comfort and other reasons(6). If windows are to be kept closed to keep the noise out alternative means of ventilation must be provided. This paper discusses the factors that influence the external sound insulation of buildings and also considers how acceptable thermal and ventilation conditions can be maintained.

In view of the widespread use of increased external insulation in dwellings to counteract high levels of noise and the possibility that future schemes will increase the use of such measures, it is important to evaluate the effectiveness of existing schemes and their acceptability to residents. BRE is currently undertaking a study of the noise insulation package provided under the Noise Insulation Regulations. The insulation provided by the package in practice has been measured and the results are described. A questionnaire survey of residents' attitudes to the package and to their internal environment has been undertaken and some preliminary conclusions are presented and discussed.

EXTERNAL SOUND INSULATION

The first point to note about the insulation provided by a building against external noise is that its overall value will be determined mainly by the performance of the weakest link. Thus in most buildings the degree to which external noise levels are attenuated will depend on the window construction and whether or not windows are opened. The only situations when this may not be so are: first where there are direct airpaths such as air bricks; second where other parts of the building structure are of very lightweight construction and third when the building has double windows.

Throughout this section sound insulation will generally be expressed in terms of the level difference between noise measured in dB(A) at 1 metre from the facade and in the centre of the room. It is important to remember that when the insulation is expressed in this way the value obtained will depend on the spectrum of the external noise and on other factors such as window size and amount of absorption in the room. For a given noise source and type of building the variation due to these factors is likely to be small. However results obtained, say in dwellings subjected to road traffic noise, may not be directly applicable to offices that are exposed to aircraft noise.

When single windows are open the noise reduction will depend mainly on the open area. A figure commonly quoted is 10 dB(A). This would apply to the situation where a substantial proportion of the area which can be opened is, in fact, open. In dwellings where it is often possible to achieve smaller openings by using transoms the noise reduction may be as high as 15 dB(A). When single windows are closed the noise reduction will depend mainly on the thickness of glass and where the window is not fixed, the effectiveness of the seal around the sections which can be opened. Typical average values for facades exposed to traffic noise with openable windows of 4 mm glass vary from 20 dB(A), for buildings such as offices or schools with large window areas and lightly furnished rooms, to 27 dB(A) for dwellings with much smaller window areas and rooms that are very sound absorbent. Increasing the thickness of the glass will increase the insulation by about 3 dB(A) for a doubling of thickness for fixed windows. For openable windows the benefits of using thicker glass may not be found unless efforts are made to ensure that the window seals well when closed and that this seal is maintained throughout the life of the window.

In order to achieve much higher values of insulation it is necessary to use double windows. The thickness of glass and quality of sealing are still important but a third parameter, the cavity width, must also be considered. The presence of two panes of glass with an air gap between results in a resonance which increases transmission through the double window at low frequencies. In order to minimise the effect of this resonance it is necessary to have a reasonably wide cavity width of, say, 150-200 mm. While double windows with much narrower cavity widths may give improved insulation at high frequencies, the performance at low frequencies will often be little better than that of a single window of the same overall weight.

Once double windows are fitted it is necessary to consider sound transmission paths through other parts of the building envelope. Measurements undertaken in houses subjected to aircraft noise(7) have shown that there can be significant transmission down chimneys unless fireplaces are blocked and through roofs, unless there is a sound absorbing quilt within the roof space. It should be possible to achieve an insulation of 35 dB(A) in houses of traditional construction with double windows. The average performance of 154 rooms insulated under the Noise Insulation Regulations is shown in figure 1. Some dwellings with a lower than average performance, particularly at low frequencies, were found to have lightweight facades. The highest results found indicate that it may be possible to achieve a noise reduction of up to 40 dB(A) in dwellings but it would be difficult to achieve such a high performance consistently, at least with remedial treatment. The results of these measurements on dwellings with the Noise Insulation Regulations package indicate that an overall insulation of 35 dB(A) is not being limited by sound transmission through the ventilator units, though there may be some effect when the insulation reaches 40 dB(A).

Where values of insulation of 40 dB(A) or above are required it will be necessary to give this aspect of performance a high priority when designing the buildings. At least one pane in the double window will have to be fixed and it will probably be necessary to use heavy glass with a wide cavity. Mounting the glass in neoprene gaskets may assist by increasing damping and isolating the panes(8).

VENTILATION REQUIREMENTS

There is rather more to increasing the insulation of buildings against external noise than simply installing double windows. In buildings without mechanical ventilation systems, windows are the main means of providing ventilation. Even when windows are closed, cracks around openable sections may provide adventitious ventilation. The installation of double windows will reduce this adventitious ventilation while opening the windows will seriously reduce the sound insulation potential of the double windows.

In specifying an insulation package for dwellings subjected to high levels of road traffic noise, it was necessary to consider three main reasons for supplying fresh air to a dwelling:

a) Control of odour and condensation.
b) Control of summer temperatures.
c) Air for combustion appliances.

Sufficient air for the control of odour and condensation may be obtained through adventitious openings with occasional opening of windows particularly in bathrooms, kitchens and toilets. Much higher ventilation rates may be required to maintain comfortable conditions in summer. Calculations of temperatures in living rooms and bedrooms on sunny days were made and the results compared with a summertime temperature standard based on BRE research on thermal comfort. This research indicated that it was necessary not only to control the mean indoor temperature but also to prevent too great a variation about this mean value. It became clear that for windows on the sunny side of the dwelling it would be necessary to provide venetian blinds between the double windows in addition to a fresh air supply. For certain combustion appliances it is necessary to supply fresh air for combustion and in the case of flueless appliances also to dilute the combustion products in the room.

The solution adopted for the package installed under the Noise Insulation Regulations was to fit a powered ventilator unit and a permanent vent in each room. The latter was provided to reduce the back pressure on the powered ventilator which would be created in a well sealed room and which would tend to reduce its efficiency. Both the powered unit and the permanent vent have been designed to attenuate incoming noise to such an extent that an overall attenuation of traffic noise of 35 dB(A) can be achieved.

It has been suggested that it may be possible to rely on natural ventilation when double windows are fitted without totally losing the sound reduction benefits of the windows. This would be done by 'staggering' the openings of the double window with the outer and inner panes open on different sides. The results of one study(9) suggest that it may be possible to obtain a ventilation rate of 2-3 air changes per hour under certain conditions while maintaining an insulation of about 27 dB(A). Unfortunately the ventilation obtained with such an arrangement, relying as it does on natural ventilation, will depend critically on wind conditions, temperature differences between the inside and outside of the building and whether there will be significant cross ventilation within the building. A BRE digest(10) discusses the mechanisms that govern natural ventilation. It is unlikely that the use of double windows with staggered openings would provide sufficient ventilation to maintain thermal comfort consistently but it may be an acceptable option for rooms with low ventilation requirements such as north facing bedrooms.

It can be seen that a major problem when designing an insulation package that would be suitable for all dwellings is in specifying the amount of alternative ventilation which should be provided. Since the ventilation requirements will vary from individual to individual and the ventilation rates obtained will depend on usage of the dwelling (for example whether cross ventilation is used) and meteorological conditions, certain assumptions have to be made. The current Noise Insulation Regulations package is based on a moderately worst case assumption and this will mean that in some situations the full ventilation capability will not be required. The adoption of such an assumption is clearly important where there are safety implications but it can also be argued that for considerations of comfort there is little point in installing a remedial package that will result in unacceptable thermal conditions in a significant number of situations.

A SURVEY OF ACCEPTABILITY

Schemes for remedial treatment to increase the insulation of dwellings against external noise have been in operation for about 17 years. The insulation packages installed in dwellings under these schemes are designed not only to keep out the noise but to permit acceptable thermal conditions to be maintained and to provide adequate ventilation. Photographs of the elements of the insulation package installed under the Noise Insulation Regulations are shown in figures 2 and 3. BRE are currently undertaking a study of the acceptability of this particular package to residents.

A questionnaire survey of almost 900 residents has been carried out at 24 sites subjected to noise levels from 68-82 dB(A) L_{10} (18 hrs). The questions were divided into a number of broad categories. The initial questions were concerned with likes and dislikes of the area and the house, this being given as the subject of the interview. The next set of questions concerned details of the house, including which rooms had been treated and the type of heating used. There followed a series of questions concerned with the respondents' feelings about individual items of the package and subsequently by a section dealing with attitudes to noise. The next section was concerned with other aspects of the internal environment in the dwelling and included questions about thermal and ventilation conditions and about condensation. The questionnaire concluded by seeking the respondents' attitudes to the remedial package as a whole.

A large majority (89%) liked the double windows. The main advantage was considered to be that they kept out the noise but some respondents liked them because they conserved heat and reduced draughts. The main disadvantages of the double windows were that they were difficult to clean and to remove when required. The venetian blinds were also generally liked (78%) but a significant proportion of residents (39%) disliked the ventilators. The main disadvantages concerned their appearance and the fact that they let in draughts.

The reduction of noise produced by the installation of the package appears to be sufficient to produce an acceptable internal noise environment in most cases. Almost 80% of residents considered that their insulated living rooms were satisfactory with regard to the amount of traffic noise while only 3% were very bothered by traffic noise in the living room. The situation was considered to be only slightly less satisfactory with regard to bedrooms.

It is interesting to note that many people continue to open windows for fresh air in insulated rooms. This is more common in bedrooms where windows may be opened during the day when rooms are not occupied. There is some evidence that the number of people opening windows in insulated rooms is less than in uninsulated rooms. Approximately half of respondents claimed that they never used the fans in the ventilator units in order to provide fresh air. Of those who used the ventilators almost three-quarters considered that the units gave enough fresh air on their own. The ventilator specification included a restriction on the noise generated by the fans themselves. As a result, fan noise does not seem to have been a general problem although 15–20% of respondents who used the fans found the noise they generated disturbing.

CONCLUSIONS

Consideration of the insulation of buildings against external noise leads to the following conclusions:

(1) For buildings with single windows the overall insulation is mainly dependent on the insulation provided by the windows. Typically the effective insulation values may vary between 20 dB(A) in schools or offices and 25 dB(A) or more in dwellings with small window areas and well furnished rooms.

(2) In dwellings of traditional construction it should be possible to achieve an insulation of around 35 dB(A) when double windows are fitted. It is difficult to guarantee higher values of insulation without careful attention to the design and construction of the whole building envelope.

(3) If high values of insulation are to be maintained under all types of building usage, it is necessary to provide alternative means of ventilation that do not require the windows of noise-exposed rooms to be opened.

(4) The insulation package installed in dwellings subjected to high levels of noise from new or modified roads appears to be generally acceptable to residents. However a significant minority find the ventilators unsatisfactory because of their appearance or because they create draughts. Despite the fact that the ventilators provide adequate fresh air when used, many residents continue to open windows in insulated rooms to provide fresh air.

ACKNOWLEDGEMENT

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FIGURE 1

Reduction of road traffic noise (L_{10}) provided by double windows installed under the noise insulation regulations'

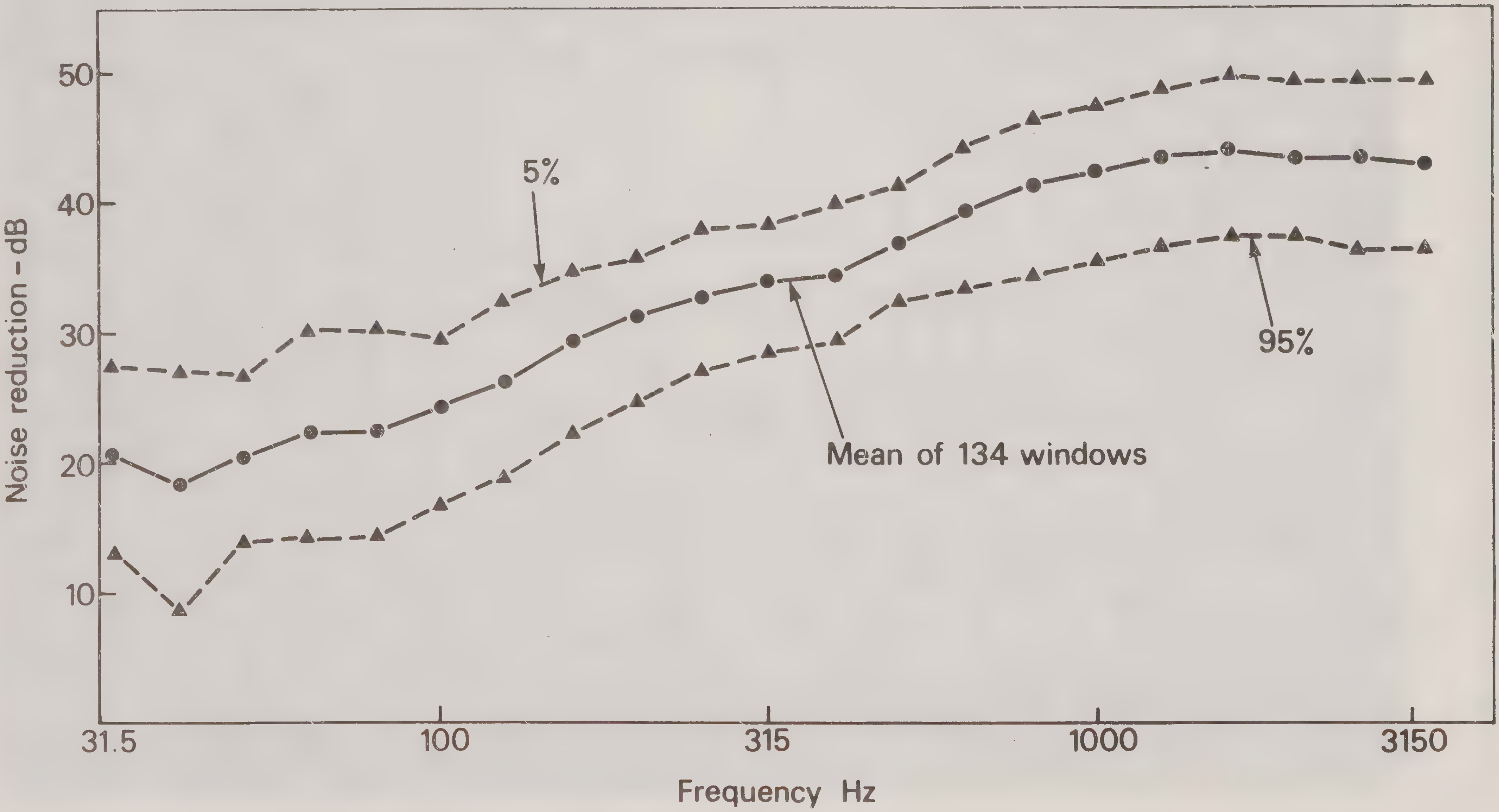


FIGURE 2: Venetian blind between double windows.

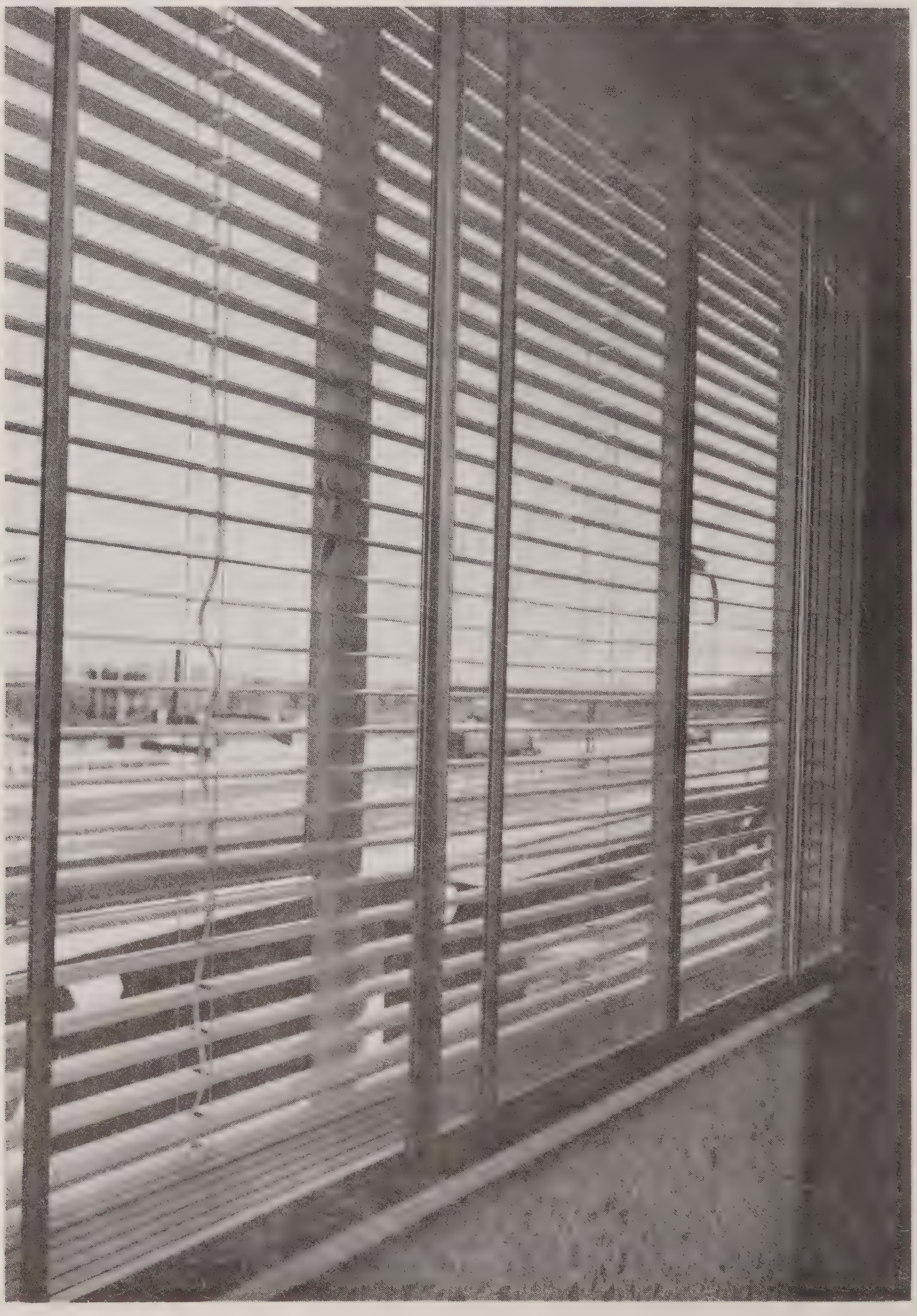
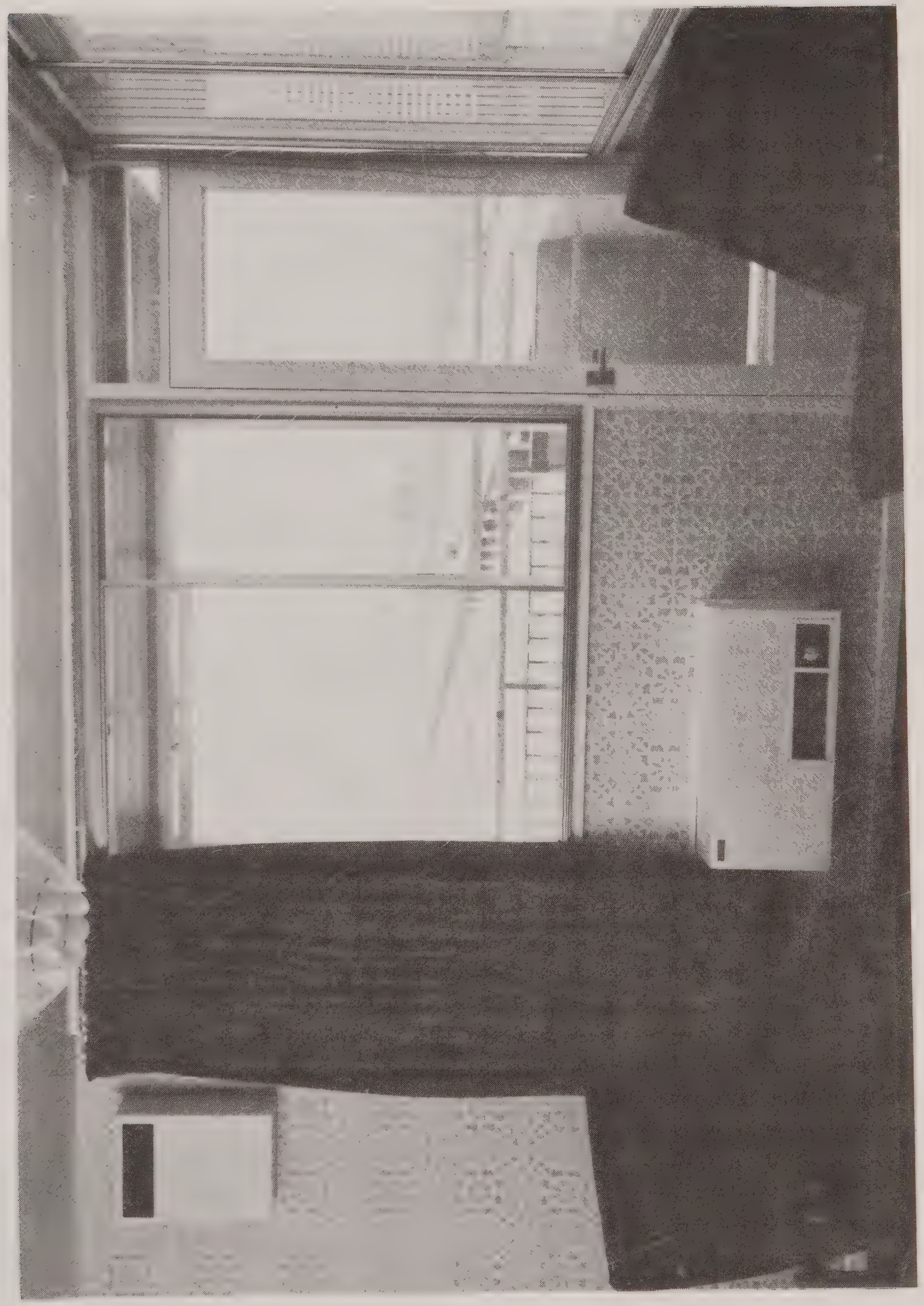


FIGURE 3: Ventilator unit and permanent vent.



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TRANSPORTATION NOISE CONTROL THROUGH PLANNING

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If one were to assess the relative importance of noise from traffic and other sources based only on the number of complaints made, it would seem that transportation noise makes an insignificant contribution in its effect on the environment. Statistics from the Institution of Environmental Health Officers for 1981 show that social and domestic related noise accounts for 30,289 of the complaints received, industrial and commercial for 18,925 and transportation noise for only 1,268. On the other hand if the comparison is based on social surveys, the position is reversed, and a recent survey 'Road Traffic and the Environment' (SCPR.1978) showed that half the population is bothered by traffic noise to some extent and this is the single most widespread source of annoyance, with 23% of the population annoyed followed by animals (16%), children (14%), aircraft (13%), people (8%), factories (4%), construction (3%), and trains (2%).

This apparent anomaly can however easily be explained. In the case of noisy parties, barking dogs, discotheques, or factories for example, the source and those responsible for it can usually be identified, and the potential complainant feels that something can be done about it, if sufficient pressure is applied through the authorities or the courts. In the case of road traffic and to a lesser extent aircraft, far larger numbers of people are affected but those disturbed cannot usually identify a particular culprit, and also feel that in any case nothing can be done about it. In this Paper I would like to try and show that it is possible to do something about transportation noise, but preferably by planning to prevent it, rather than attempting to ameliorate it once the problem already exists. In considering the need to protect the environment against noise or air pollution it is of course necessary to recognise that in a modern society efficient and economic means of transport are essential both to sustain the economy and to enable people to make the most of their leisure time. Because of this, some environmental penalties may have to be tolerated but the extent of these must be minimised, and society must be prepared to give at least equal consideration to those adversely affected by transport as to those using it. Most of us come into both categories, but at different times and locations, and our attitudes seem to change accordingly.

ROAD TRAFFIC NOISE

Road traffic noise is by far the most widespread source of noise in this country and affects people not only on heavily trafficked urban roads, but also in quiet suburban or rural roads traversed by occasional but noisy lorries or motor cycles. In planning against traffic noise it is a good maxim that prevention is not only better than cure, but also usually cheaper, and the best and most equitable place to start prevention is at source.

Reduction at Source

Reducing the noise emission of vehicles can add considerably to cost but is unlikely by itself to be a useful selling point and a public spirited manufacturer making a quiet product may well be penalised by competition from cheaper and noisier products if these are permitted. Legislation is therefore required to encourage the process, and in many cases this needs to be on an international, rather than a national, scale particularly as regards aircraft and road vehicles. Considerable progress has already been made in this respect, for example by the international noise certification of aircraft, and EEC Directives on vehicle noise emissions. So far however the standards used tend to be on the generous side as far as the manufacturers are concerned, and are determined by the 'lowest common denominator', that is, the least efficient manufacturer. A positive point in this field is that EEC regulations have this year reduced the limits for the largest new lorries from 91 dB(A) to 88 dB(A), as based on ISO test procedures.

That it is feasible to achieve these and much lower emission levels has been shown for example, by work at the Institute of Sound and Vibration Research at Southampton University, the Motor Industries Research Association and the Transport and Road Research Laboratories, and there are now few problems in achieving substantial reductions. In Britain, the Quiet Heavy Lorry Project showed even in 1979 that a 10 dB(A) reduction, i.e., a halving of preceived loudness, was achievable on a 38 tonne heavy goods vehicle. In drive-by tests under BS 3425 conditions the Quiet Heavy Vehicle registered 81 dB(A) compared to 90 to 92 dB(A) prior to modification. Recent work in Germany has been even more impressive and Magirus Deutz have modifed 7.5 tonne lorries, reducing their noise levels from 90 to 74 dB(A). Technical achievements and legislation on reducing noise emission at source are not however enough by themselves, and need to be backed up by an efficient enforcement procedure, and in many cases it can be this latter aspect which causes the real problem.

There are limits however on the extent to which vehicle noise can be reduced, and this relates not only to the engines, but also to factors such as tyre/surface interaction, the packing of loads, and aerodynamics. It is also difficult to ensure that a new quiet vehicle will remain quiet after a few years and much will depend on maintenance by the owners and control by the authorities. Thus while reducing vehicle noise is an essential element in a noise control policy, it must be recognised as a long term method, and for many years yet we will have noisy vehicles on the road.

Prevention by Planning

The other obvious method of preventing a noise problem is by the separation of noise producing and noise sensitive developments. Obvious though this is, it has not often in the past been a point seriously considered in town planning or in the granting of planning permission for new developments. At the planning stage, if noise is taken into account, much can be done; for example the route of a proposed road can be chosen so as to affect the minimum number of dwellings, or conversely proposed new dwellings or schools should where possible not be permitted in an existing noisy environment. When new roads were planned in the past, noise was not usually one of the main factors in deciding on the optimum route. This has now of course changed and in the United Kingdom all road schemes, even before public consultation takes place, are thoroughly examined to assess their environmental, including noise, implication. A detailed procedure for estimating the effect of noise, and for estimating the number of people likely to be affected by alternative schemes is carried out, and environmental considerations play an important part in the final route selection. These studies have now become an essential element of the environmental assessment of new road proposals and are subject to critical scrutiny both by those proposing and those opposing road schemes at public inquiries.

It may not, however, always be possible to choose a route away from residential developments and other methods then have to be used to minimise potential noise problems. In the actual design of the road, it may sometimes be justifiable, in spite of the high additional cost, to construct a road in 'cut' so as to reduce the noise emission, or to incorporate noise barriers in the design. Barriers are especially effective for elevated roads near low rise housing, and if they are part of the original design rather than as a remedial afterthought, can be visually acceptable and not too expensive.

Traffic can also be prevented from becoming a noise problem, by the appropriate use of layout and design of new housing development, and many ingenious solutions have been developed by architects to enable people to live under acceptable conditions, quite close to major roads. These include the use of single aspect design where kitchens, bathrooms and access balconies face towards the traffic, and bedrooms and living rooms face away from it. In other cases garages or storerooms have been used as barriers to screen dwellings, and on a smaller scale balconies can sometimes also provide protection. As a last resort, sound insulation incorporated in the design of new housing is more effective and acceptable than when provided as a remedial measure, and where necessary can be used to protect noise sensitive rooms in 'barrier blocks' which themselves can provide screening for other blocks or recreational areas.

Existing situation

Unfortunately our cities and towns have so far mostly developed without sufficient thought being given to noise prevention, and serious noise problems do exist and need to be reduced as far as is practicable. In doing so account must be taken not only of the desire for a quieter environment but also of the costs in economic terms of providing it. This does not relate only to actual remedial measures, but also to restrictive effects on local transport and industry and consequentially on employment potential. It is also important not to solve a traffic noise problem in one area merely by moving the traffic from one locality to another, just because the population in the first locality is better organised and better able to protest than that in the second area.

Basically there are three methods of reducing existing traffic noise. The first relates to the source, i.e., the traffic itself, and requires restrictions on or complete banning of certain types of vehicles, or even complete re-routing of traffic. In considering traffic management as a tool for noise control it is useful to remember that concentrating traffic on to selected routes can often provide the optimum conditions for an area as a whole. On an already busy and noisy road, even substantial increases of traffic of say 25% in volume, will have no perceptible effect in increasing the noise level. On the other hand, removing that volume of traffic from minor roads may provide substantial benefits. In any case, in considering traffic management measures designed to improve traffic flows, noise and air pollution aspects are now always taken into account to ensure that as far as possible they can also be used to provide a net environmental benefit for the majority of people. More limited measures include traffic restrictions, for example the banning of heavy commercial vehicles from residential roads, particular at night. This can provide substantial benefits for many people living in residential areas merely at the cost of a few traffic signs and appropriate enforcement. If this is done it is however also necessary to provide carefully located lorry parks, where these vehicles can stay overnight and leave early in the morning without creating a problem in a new area. The Table below shows the effect on noise levels of banning all lorries in a minor road, and transferring these on to a major road. This leads to an appreciable noise reduction in the minor road and no perceptible increase in the major road.

Effect on noise levels of transferring all trucks from a minor to a major road

Traffic volume – vehicles/hour   Speed 40 km/h

	Before transfer		Transfer	After transfer		Change L_{10} dBA
	Total	Trucks	Trucks	Total	Trucks	
Major Road	3000	1200 (40%)	+30	3030	1230 (41%)	0.0
Minor Road	300	30 (10%)	-30	270	0 (0%)	-4.0

The second method relates to the transmission path between the source of the noise and the listener, and requires the use of some form of screening. This can be very effective in certain cases, but can be expensive and can introduce new problems such as visual intrusion. Barriers need to be located as close as possible to the road, and to be as high as is practicable. They do not however need to be heavy as the limiting factor will nearly always be noise passing over them, rather than through them. Often a close boarded timber fence will provide a good improvement, although purpose built barriers, such as on the M4 at Heston, are particularly effective. Where there is a reasonable distance between the road and the development, screening can also be in the form of non-noise sensitive structures such as garages or sheds. There are many cases, however, where barriers would be impracticable or ineffective, such as for example in the case of high rise buildings near the road.

The third and least desirable form of reduction, but often the only solution, is at the receiving end where sound insulation can be provided. There are no practical difficulties in providing very effective insulation, for example by the use of good double windows, but there are several disadvantages. Firstly, resources spent on insulation can only provide protection for those indoors and cannot be used to provide a good environment for gardens and outdoor areas. Secondly, to be effective windows need to remain closed, which is a restriction on the occupants, and usually necessitates the use of mechanical ventilation. Thirdly, insulation particularly with mechanical ventilation, is expensive, and the cost may have to be borne by those affected rather than by the polluter which would be more equitable. In spite of the disadvantages, sound insulation, being the only remedy often available, is widely used in the United Kingdom and other countries to reduce the effect of noise, particularly from aircraft and road traffic.

Compensation

Although much can be done by preventive or remedial measures there are unfortunately still many cases where there is no satisfactory method of reducing the effect of traffic noise. In those cases some form of compensation - usually financial - has to be considered.
Under the Land Compensation Act 1973, Section 1 provides for financial compensation to be paid under certain circumstances when a new road or other public works causes a loss of value in a property due to noise or other pollution. The extent of this is determined by

the District Valuer and the Act gives no indication of the extent of payment to be made for various degrees of pollution. Under Section 20 of the Act, Noise Insulation Regulations were issued in 1973 and 1975 which specify that if a new road is built, or an existing road widened and if as a result the noise level is expected to increase within the next 15 years, and to exceed a specified level of 68 dB(A), L_{10} (averaged over 18 hours 0600 to 2400 hours), insulation may, or in some cases must, be offered to the occupant by the Highway Authority. The quality of the insulation is specified and mechanical ventilation must also be provided. This form of compensation is however only available if the increase in noise is due to a new road or to a physical alteration of an existing road. It is not available if the increase, however large, is due merely to new traffic schemes, or an increase in traffic in a newly created feeder road caused by construction elsewhere. The present situation in this respect is clearly unsatisfactory and the possibility of widening the Regulation is being considered for the future, but it would of course have serious financial implications. Even under the present regulations it is estimated that so far over 60,000 dwellings have been insulated at a cost of approximately £1,000 per dwelling.

There is also a possibility for compensation by means of a reduction in the local rates, if it can be shown that the value of a dwelling has been reduced because of excessive noise. There are no general rules on this and the extent of rate reduction varies from area to area but is generally small.

RAILWAY NOISE

Before leaving surface transport, a brief mention needs to be made of railways. Although railways can be, and often are, sources of high noise levels, there appears to be little evidence of widespread annoyance or disturbance due to this. Partly this is because unlike road or air traffic no new routes or increased levels of traffic have recently affected people, and partly this may be because of a general acceptance of railways as an essential element of the transport system used by all. Furthermore most people affected by railway noise have either grown up with it or moved into houses fully knowing that these are affected by railways.

Work at the British Rail Research Establishment in Derby on means of reducing noise both from the power propulsion unit and from rail-wheel interaction, as well as the introduction of long welded rails have led to considerable improvements. The most serious problems remaining relate to railway goods yards and shunting operations, but that is a separate subject.

In the case of planning new noise sensitive developments close to existing railway lines, similar considerations to those for road traffic apply, but in addition emphasis has to be placed on protecting dwellings against vibration.

AIRCRAFT NOISE

The relationship between the community and its airport(s) is to a large extent a 'love/hate' relationship. The airport brings clear advantages to the community in terms of travel facilities, trade and employment, and the size of the airport or airport system is a good indication of the importance, affluence and sophistication of the conurbation it serves - it is thus also a prestige symbol. On the other hand it can also bring disadvantages such as local traffic congestion, pollution and, of course, noise.

An airport affects the environment at two levels - local effects of the airport itself on its immediate surroundings, and the noise from aircraft using the airport which, although decreasing with distance from the airport, still affects people several miles away. In considering methods of protecting the environment, account must be taken of both problems while at the same time recognising the need for the airport to remain viable both from the economic and an operational point of view. In this context it is also important to realise that in mitigating the effect of aircraft noise the responsibility is not exclusively with those causing the noise, i.e., the aircraft and the airport, but also relates to the recipients, i.e., noise sensitive developments on the ground.

Planning against aircraft noise

As for surface traffic, prevention is better than cure and in the case of aircraft noise, this is particularly relevant. Once an airport and its related infrastructure is established, it cannot generally be moved, and with uncontrolled development near it, conflicts are bound to arise. The most important stage is therefore the selection of an acceptable site. In making environmental assessments of potential sites, the main criterion is of course the number of people likely to be affected by noise, both around the perimeter of the airport and under the flight routes. This will depend not only on distance, but more importantly, on runway alignment which is determined by prevailing wind and air traffic considerations. At an airport with single or parallel runways, noise disturbance falls off rapidly to the sides, but extends a long way in line with runways. This is particularly evident for example, in the case of London (Heathrow) Airport where the problem is not so much the proximity to London, but the alignment of the runways. If a similar size airport at the same distance from the centre of London were to have been situated north or south of the capital, far fewer people would have been affected. Recently released Cabinet papers show however that when Heathrow was first developed as a major airport, consideration of the environment was an aspect conspicuous by its absence.

Reducing aircraft noise

Reduction at source is the ideal solution and considerable progress has been achieved with modern wide bodied aircraft being substantially quieter than the earlier generation of jets. This has not been brought about by the altruism of manufacturers or airlines, but by the introduction of international noise certification limits by the International Civil Aviation Organisation and the United States Civil Aviation Administration following persistent pressure by the public. In Britain aircraft coming onto the United Kingdom Register since September 1978 can only be operated if they meet noise certification standards, i.e., standards set out in ICAO Annex 16. After December 1985 all aircraft on the United Kingdom Register must be noise certificated and two years later this will also apply to foreign aircraft using British airports.

In the context of reducing the emission of noise at source, an important element is the actual procedure used in taking off and landing. Noise abatement procedures for take-off have been used at Heathrow and other airports for many years, but it is only relatively recently that procedures for reducing noise have also been established and accepted. There is no doubt that noise emission can be reduced for both take-off and landing, but three points have to be considered. Firstly, however important the environment, safety must always come first and noise abatement procedures cannot be allowed to prejudice safety; secondly, extra costs in terms of fuel used are often involved, and thirdly, a reduction in very high noise levels for some people may cause an increase in the number of people whose existing relatively good noise climate may somewhat worsen, or vice versa.

At established airports the designation of flight paths for departing aircraft so as to minimise the number of people affected is probably the most important feature of noise abatement policy. These flight paths (minimum noise routes) are selected to fly over open spaces or lightly populated areas as far as possible and to avoid heavily built up districts. Again, however, safety and operational considerations must take precedence, and again the use of the minimum noise routes imposes a fuel penalty.

Noise Monitoring

In order to ensure that departing aircraft are flown in such a way as to minimise noise many airports have installed noise monitoring systems around the airport which record the noise of each flight and identify the aircraft, operator and destination. Monitors are generally placed either under the nominal flight route or to each side of it, the latter being more effective in encouraging compliance with minimum noise routes. To be fully effective, the monitoring system must enable instant checks to be made on the reasons for infringement, preferably by direct communication with the pilot, and must be backed by an administration which will take real action if infringement by a particular airline persists.

Ground Noise

The noise from aircraft on the ground is a potentially serious problem in cases where there are housing developments close to the airport perimeter. Apart from the obvious and very high noise levels associated with aircraft taking off or landing on the runways, noise from aircraft on taxi ways and at aprons may also cause problems. In some cases, noise barriers can be used to screen particular communities, but to be effective these need to be as high as possible and as near to the source as is practicable. Noise from stationary aircraft, particularly during maintenance operations which often have to be carried out at night, often gives rise to complaints. To a large extent, these can be reduced by the use of mufflers especially designed for particular aircraft, or by general purpose screens. In some cases, it has even been necessary to build special noise protection pens for particularly noisy aircraft, such as Concorde.

Actions around the airport

The onus of reducing the effect of aircraft noise is not only on those responsible in some ways for its emission, but also on the surrounding communities. People wish to live near airports because of their enhanced employment opportunities, and house prices are as high in noisy areas close to airports as in comparable quiet areas a long distance away. Airport authorities express concern when new housing estates are planned close to airports, because of the expectation that the number of people annoyed by aircraft noise will be increased, leading to greater pressures for restrictions. In the United Kingdom, guidelines on developments near airports is given in 'Planning and Noise' (Department of the Environment Circular 10/73). This shows areas defined in terms of the Noise and Number Index (NNI), where building may take place and also defines the insulation required for different categories of development in areas of high noise levels. Noise insulation can never be completely satisfactory, as however good the insulation may be it cannot be used to protect people out of doors. It is nevertheless an essential part of a noise abatement strategy, both for existing buildings, and as a conditional requirement for planning consent for new building. Up to April of this year a sound insulation scheme for residents near Heathrow and Gatwick Airports was financed by the British Airports Authority which covered the full insulation cost of two living rooms and all bedrooms in homes within a specified area around the airports. This scheme is now no longer operational, on the assumption that all those who were eligible and wished to apply would by now have done so.

HELICOPTERS AND STOL-AIRCRAFT

An increasingly important noise problem is that associated with city centre heliports and very recently, airports designed for (STOL) Short Take Off and Land aircraft. These facilities provide substantial benefits for the business community in reducing travel time on the ground, but can also cause appreciable environmental problems both in their immediate vicinity and under flight routes. Unlike fixed wing aircraft there is still no noise certification of helicopters, and attempts to rectify this in discussions extending over several years have so far been unsuccessful. The characteristic noise of helicopters, including 'blade-slap' has become familiar in London and other cities and although it is by no means as extensive problem, it is one which is likely to grow. In London, the GLC as the then planning authority, pioneered noise guidelines for helicopters, and by means of a Section 52 agreement placed limitations on the use of Battersea Heliport when it was first established. Restrictions there include a limit of 12,000 movements per annum, not more than 1,500 of which may be by noisier helicopters as defined in the agreement. There are also limitations on the maximum number of daily movements, and on the times of operation of the heliport, no night flights being permitted. Similar considerations were used in granting temporary planning permission for a heliport at Trig Lane in the City. One aspect of helicopter use which causes particular concern is that any site can be used for helicopter landing for up to 28 days per year without planning permission being required. The Greater London Council in a recent report suggested that such sites should be licensed and that stricter controls on helicopters and their routes should be brought in.

At the time of writing a Public Inquiry is in progress on the application for the first STOL port in London in the Royal group of docks. Although the aircraft intended to be initially used in operation there, the De Havilland Canada -7 is undoubtedly a quiet aircraft, this may well be the thin end of the wedge, and changes in the proposed flight procedures, increases in the number of movements initially envisaged and above all, later use by other aircraft could create a serious problem in an area of London at present little affected by aircraft noise.

FUTURE PROSPECTS - SOME THOUGHTS

In the last 20 years or so noise has come to be recognised as a real problem, but also as a problem which can to a large extent be prevented in the future. Further, but more limited, progress can be anticipated in the reduction of noise from new vehicles and aircraft, and as these gradually replace existing machines, their influence on the noise climate will become ever more noticeable. More fundamental changes need also to be considered, particularly the greater use of electric vehicles for city operations which would reduce both noise and pollution. While it must of course be accepted that electric vehicles cannot in the foreseeable future replace existing petrol and diesel vehicles there are many short distance operations where such vehicles could ideally be used. Regarding lorry noise, further thought needs to be given to lorry routes and lorry bans and the possible moral and other implications of providing benefit for the many at the cost of some worsening in the environment for the few. Motor cycle noise at present bothers more people in their homes than any other single source, and in this case future improvements depend not so much on the technology required to reduce the noise, but on correcting the impression among many young people that noise equals power. Regarding air traffic, as the position slowly improves with respect to major airports, more attention will need to be given to the growing problem of city centre heliports and small urban aerodromes intended for business traffic and/or operations by Short Take-Off and Land aircraft.

In the future, if the economic situation improves, one can expect further growth in transport and industry, and if no action were taken, this would inevitably lead to a further deterioration in the noise environment, and to an extension of the problem to previously unaffected areas. However, by the setting of realistic standards aimed at reducing noise at source, and enforcing these, by environmental planning and by education of both professionals and the public on means of reducing noise, this situation can be avoided and instead a gradual improvement in the noise environment can reasonably be anticipated.

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REVIEW OF NOISE INDICES AND FUTURE REQUIREMENTS

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INTRODUCTION

The term Noise Index is used here to mean a single-figure descriptor of the noise received from a particular source, or of a total noise environment, which is relevant to its intrusiveness or annoyance value. This paper considers neighbourhood or environmental noise affecting people whose activities at the time are not connected with the noise source.

Very few noises affecting the general neighbourhood are constant in level or character over a significant period of time. A noise index must take account of differences in noise character and of variation of level with time. Ideally, the same noise index should be equally applicable to all noise sources, but at the same time it should be simple and easy to measure and record.

This paper considers:

1. The components of a noise index.
2. The noise indices in current use in Britain.
3. Some problems and possibilities in the application and development of noise indices.
4. Conclusions from the above and suggestions for future development and simplification of noise indices.

1. COMPONENTS OF A NOISE INDEX

The two components which must be incorporated in the index are:

(i) Variation of intensity with frequency within the noise spectrum.
(ii) Variation of intensity with time over the period to be considered.

These can be considered separately.

Intensity and Frequency

The unit of noise intensity must be weighted so as to match the frequency response of the ear in a way which is relevant to intrusiveness.

(a) Continuous frequency weighting.

The simplest method of frequency weighting is to use a continuous frequency/intensity relationship. This can be built into the sound level meter so that an overall weighted sound level measurement is given. The A,B and C scales were derived for this purpose; they approximate to equal-loudness weightings relating to low, intermediate and high noise levels. The A-weighting seems to be relevant to all normal levels of neighbourhood noise and is the only one now commonly used.

A fourth weighting, D-scale, is sometimes used for aircraft noise (1).

A direct sound level reading in dB(A) is adequate for characterless noise. But tonal components (whine or hum) and intermittency or other characteristics (clank, rattle or thump) have an annoying quality for which some other allowance must be made. This is generally done by adding 5 dB(A) to the measured level when such noticeable characteristics are present.

(b) Block frequency weighting.

Alternative weighting systems which employ sound levels in frequency blocks such as one-third octave bands have been derived. These include noys, sones and phons of various kinds. The merits of these systems do not, in general, compensate for their added complexity as compared with A-weighting. The PN system used for aircraft noise is the only one of this type in common use, and even this is often replaced by estimates based on A-weighting.

Intensity and Time

The method of handling variation of noise level with time will often depend on whether the readings are taken manually or automatically. If manual readings are taken with a hand-held meter, eye-estimates can be made of, for example:

- mean low level
- average level (provided fluctuations lie within a band of about 10 dB)
- maximum level (instrument dynamics limit ability to measure this with impulsive noise)

If readings are taken and processed automatically, more sophisticated and precise statistical parameters can be used.

(a) Statistical levels.

Commonly used parameters are L_{10} (the level exceeded for 10% of the time), and L_{90} (the level exceeded for 90% of the time). The logic is that:

- where noise level fluctuates, the high excursions have a major influence on intrusion so L_{10} is appropriate
- where there is a general background level on which other varying noises are superimposed, the L_{90} may best represent the background noise.

(b) Equivalent continuous level.

The equivalent continuous sound level, L_{eq}, is the constant level which would represent the same integrated sound energy as the fluctuating level noise in question over the same time period. Numerically:

$$L_{eq} = 10 \log_{10} \frac{1}{T} {}_{0}^{T} (\text{antilog}_{10} \frac{L_t}{10}) \, dt.$$

The received L_{eq} over a period of time is the "noise dose". It is logical to suppose that physiological response such as hearing damage is a function of noise L_{eq}, but the logical connection with intrusion and annoyance is more tenuous. It seems likely that L_{eq} correlates reasonably well with annoyance fortuitously because it is a level somewhere between the average and the maximum.

L_{eq} is a very convenient parameter because it is a mathematical quantity which takes the whole noise level history into account and individual L_{eq} values can be processed and combined mathematically. Indeed, its very elegance carries the risk that it may be used even where it is not relevant.

2. NOISE INDICES IN CURRENT USE IN BRITAIN

The majority of indices use A-weighting to take account of the intensity/frequency component. The symbol L when used in L_{10}, L_{eq} etc. indicates level in dB(A).

Different indices have been developed or have come into use in connection with different noise sources and situations.

(a) Total Ambient Environment

There is no established index for total ambient environmental noise level. L_{eq}, L_{10}, and L_{90} or other parameters may be used. It is generally relevant to consider day and night periods separately.

Environmental noise is commonly measured with respect to establishing the "background" noise, or contributions from specific sources such as road traffic or industrial activity.

(b) Ambient Background

BS 4142 (2) calls for background noise to be measured as L_{90} or mean low level.

(c) Road Traffic

It has been found that annoyance caused by road traffic noise correlates reasonably well with L_{10} (18 h). This is the L_{10} measured during the 18 hour period 0600-2400 on working days. Night-time and weekend noise levels are not taken into account.

The time-related factors relating to annoyance include variation in traffic type and density and variation in the activity of the resident - indoor/outdoor, speaking, listening, sleeping. It is apparently fortuitous that the typical effect of these variables taken together is such that weekday time is commonly the controlling period with respect to annoyance.

L_{10} is the index used for describing and predicting road traffic noise and for deciding on statutory planning measures and compensation.

(d) Air Traffic

Air traffic is more difficult to deal with because it causes separate peaks of high level but short duration.

Social surveys in the neighbourhood of Heathrow showed that annoyance correlated reasonably well with Noise and Number Index (NNI) over the 12 hour day period 0600-1800. Aircraft noise level was conventionally measured then as Perceived Noise Level (PN dB)(3), which is a frequency block weighting system, rather than in dB(A).

The NNI is given by:

$$NNI = \bar{L}p_{Nmax} + 15 \log_{10} N - 80.$$

where: $\bar{L}p_{Nmax}$ is the logarithmic mean* of the individual aircraft passage peak levels

N is the total number of aircraft passages.

NNI is the index used for planning and compensation purposes.

* Logarithmic mean $\bar{L}$ is given by $\bar{L} = 10 \log_{10} \left(\text{antilog}_{10} \frac{L_1}{10} + \text{antilog}_{10} \frac{L_2}{10} + \ldots\right)$

The relevance of a daytime only index to annoyance is probably fortuitous for air traffic as it is for road traffic.

(e) Industrial Premises

Noise from industrial and commercial premises is very variable in character and level. It is dealt with in BS 4142. Social surveya in several countries have shown that annoyance correlates reasonably well with Corrected Noise Level (CNL) related to the "background" level.

CNL is not authoritatively defined, nationally or internationally, and there is some variation in usage. In general it means noise level measured in dB(A), suitably adjusted if it varies with time and corrected for the presence of tonal or other characteristics.

BS 4142 sets out its own procedure for determination of CNL.

3. SOME PROBLEMS AND POSSIBILITIES

The systems of noise indices used in other countries are generally similar to those in Britain because they were derived in similar ways at much the same time and there has been continuing international dialogue and some standardisation. Even so, some rather fundamental questions spring to mind.

1. How should total ambient noise be evaluated?
   We do not have an accepted index for this.

2. What is the cumulative effect of different classes of noise?
   Each index is based on likelihood of causing annoyance individually and different units are used.

3. Why do we not have a simple industrial noise index?
   The CNL does not have an established simple

mathematical definition like that for NNI, and in any case it is compared with background noise.

4. What about other sources?
   We do not have simple established indices for noise from social or recreational activity, temporary or mobile industrial activity or railways.

Before discussing these questions one should consider objectives and practicalities.

Objectives

The practical objective in deriving noise indices is to be able to evaluate the social effects of noise-making activities. On this basis, statutory controls can be set and systems of compensation or amelioration devised where appropriate.

In most cases where noise is a problem, one class of noise source is dominant. In each class of noise source generally only one statutory body and one group of operators are involved. It is therefore quite reasonable to treat each class of noise source separately. The practical objective is thus not impeded even if different indices are used for different classes of noise source.

There is now a new objective, to describe the whole noise environment in one universal noise index to be used for large-scale planning purposes. This is an interesting idea but it is rather less urgent and action-oriented than the initial objective of creating a basis for immediate specific positive controls, protective measures and compensation.

Practicalities

A noise index can be as elaborate and precise as mathematics and electronics will permit. A prediction of noise annoyance, however, can be no more than a rough estimate within a statistical framework.

When it comes to controls and corrective action, other socio-economic factors will apply. One cannot do more than the best practicable in any case. Socio-economic considerations, technical practicability and the long term fate of land-use planning are all liable to change with the passage of time.

We should try to bring order out of chaos - where chaos still obtains - but order will never be perfect. Pragmatic approximations rather than elegant precision are the realistic targets for practical noise indices.

(a) Total Ambient Environment

Equivalent continuous level, L_{eq}, is the simplest and most flexible index of varying noise. In common with any average, L_{eq} may conceal as much as it reveals, but simplicity is a virtue. It can be used in a formal definition of CNL along the lines:

$$CNL\ (t) = L_{eq} + C$$

where: t is the time period over which the CNL applies, say 16 h (0600-2200) or 8 h (2200-0600)
C is a correction for noise character, say 5 dB(A) if noticeable character present.

The ISO is trying to work towards the adoption of L_{eq} as a universal ambient noise index in its current revision of ISO 1996 (4). This visualises the use of long-term L_{eq}, but it is difficult to see the relevance of L_{eq} over a period of more than a day. A series of noisy nights can hardly be compensated for by the memory of quiet nights some time before, and year-round L_{eq} can hardly be meaningful.

An alternative approach is the Community Noise Equivalent Level (CNEL). This, like CNL, is not authoritatively defined but is a form of block L_{eq} with correction factors for day, evening and night. One wonders how far a quiet day can compensate for a noisy night, or vice-versa. Day and night time-blocks really ought to be considered separately.

Another alternative is the Noise Pollution Level (5). This is based on L_{eq} with a factor for noise peaks. It is a good concept, but at this stage a new index can hardly be justified.

On balance, it seems that CNL considered in time-blocks within each day, CNL (t), is the most appropriate and promising simple index. Day to day variations and temporary activities of a few days' duration would have to be considered individually on their own merits.

(b) Ambient Background

The mean low or L_{90} is a simple and reasonable index of the basic existing background noise, but is it an appropriate index for comparison with noise from existing or planned new developments such as a motorway or a factory? This is discussed further in (e) below.

(c) Road Traffic

For the existing statutory provisions, L_{10} is adequate.

If road traffic noise is to be taken into account as a component of ambient noise, a compatible index must be used. If an index such as CNL (t) is adopted, it will be sufficient to measure road traffic noise as L_{eq}; it can then be handled in the same way as industrial noise discussed in (e) below. This should present no great problem. In general, for road noise:
$L_{eq} = L_{10}-3$ dB(A) approx (6)

(d) Air Traffic

For the existing statutory provisions, NNI is adequate.

The pattern of aircraft noise is so different from that of other noise that a special index is more easily justified. The most questionable part of the NNI is the use of PNdB rather than dB(A). PNL is, arithmetically, an unwieldy unit. In practice PNdB is commonly estimated by adding 13 dB to the dB(A) Level (10).

BS 5727 gives procedures for measuring aircraft noise in dB(A) and deriving L_{eq} and other indices in terms of dB(A). The objection to L_{eq} is that it does not take into account adequately the short term peak nature of the noise, but a noise event index or NNI based on L_{Amax} rather than L_{pNmax} can be used to simplify measurement and correlation with other environmental noise. One of the objects of the noise pollution index, L_{NP}, was to take account of peak noises such as aircraft noise; but for correlation with other noises it would be necessary for all noise to be measured in L_{NP}.

(e) Industrial Premises

As discussed above, the CNL used in BS 4142 is not very different from a corrected L_{eq} index. The existing ISO 1996 (7) approach is closer and the current revisions of ISO 1996 (3) are working towards corrected L_{eq} as a universal index. However, the drafting of the new ISO 1996 has run into considerable difficulties and it is impossible to forecast what and when the outcome will be.

The exceptional feature of the application of CNL to industrial premises is that it is compared with background noise, either existing or notional. The logic is that it is accepted that road and air traffic noise will inevitably be dominant in the areas most affected whereas factory noise can generally be controlled so that it is not dominant. Thus the concept of comparison with and control in respect to background noise is reasonable.

However, the use of different indices for factory and background noise can be misleading. If factory noise is numerically equal to background noise, one might conclude that adding the factory would increase total environmental noise level by 3 dB(A). This is not necessarily so.

"Background" noise level is taken as L_{90}, so the actual non-factory noise exceeds this for 90% of the time. If the factory noise is reasonably steady it is taken as the average, or approximately L_{50}, and so is below this for 50% of the time. Thus if factory noise equals background noise level numerically, the factory noise level will in fact be below "background" for most of the time; the actual proportion will be between 50% and 90% of the time depending on the respective noise variation with time.

If the neighbourhood location is some distance from the factory, say 100m or more, the noise level received will vary with wind and weather conditions (8). Noise matters most when it is loudest, and wind direction is the most important meteorological parameter, so distant factory noise should always be measured when downwind of the factory. This is required under the Noise Measurement Regulations in Britain (9) and is standard practice in Germany.

There is not an agreed symbol for downwind noise level, but L_{dw} is clear and convenient. L_{dw} can be measured as a spot level or an L_{eq}. Considering again factory noise relative to background, if L_{dw} is numerically equal to background noise level, on most days the factory noise will in fact be below background because on most days the measuring location will not be actually downwind of the factory. Even on the downwind days the factory noise will be below background for most of the time because it is an L_{50} or L_{eq} while background noise is L_{90}. So even with a numerically equal level, the factory will tend to add little to the total ambient noise long-term.

Measurement Methods

The development and definition of a noise index is primarily a paper exercise, but taking the specific measurements relevant to the index is a very practical matter. Modern statistical sound level recorders can measure and record parameters such as L_{10}, L_{90} and L_{eq} over short or long periods. But the meter measures only the total noise incident on the microphone; it cannot distinguish road traffic or industrial noise as such. The level recorded will relate to a specific source only as long as that source is dominant, and the recorder cannot tell when this is the case.

All neighbourhood noise measurements relating to specific sources must therefore be manually controlled or supervised. With road or air traffic noise it is generally possible to set a threshold above which the noise in question is known to be dominant and below which measurements are not required; in this case the recorder can be set and left to work automatically.

With noise from industrial premises or distant roads this is seldom the case and more or less constant supervision is necessary. Supervision alone does not eliminate all doubt because the decision as to whether the source noise is dominant is a subjective one in most cases. If there is likely to be dispute as to the validity of data, it is necessary for representatives of the interested parties to be present when these decisions are made (9).

The need for supervision limits the amount of relevant data which can be collected and means that in many cases only spot readings or short-period L_{eq} can be taken.

4. CONCLUSIONS

At first sight the diversity of noise indices is disquieting. However, this diversity arises logically from their origins and purposes and does not seem to present any great practical problems.

There is a case for some rationalisation of the CNL used in connection with industrial premises. There is also a case for continuing the move towards a unified system, based on noise level measured in dB(A) and time average in the form of L_{eq}, as and when opportunity arises.

The following would seem to represent appropriate guidelines for future development of indices.

(a) Total Ambient Environment

Time-block corrected L_{eq} over periods say 0600-2200 and 2200-0600, denoted by:- CNL (t) dB(A)

The present notional 5 dB(A) correction for noise character should be retained until something better is derived.

Long term (more than one time-block) L_{eq} seems unlikely to be useful in practice.

(b) Ambient Background

Time-block L_{eq} and/or L_{90}. Time blocks as in (a).

The merit of L_{90} is that it requires less supervision for exclusion of non-background noise; the disadvantage is that it is different from the other indices.

(c) Road Traffic

L_{10} (18 h) is adequate for present purposes.

Translation to L_{eq} would provide a more flexible environmental noise index for general use. The L_{eq} would have to be time-blocked as in (a).

(d) Air Traffic

NNI is adequate for present purposes.

> Formal standardisation of NNI based on noise levels measured in dB(A) is required with a procedure for translation to L_{eq}.
>
> The noise of aircraft on the ground can reasonably be measured in dB(A). Airports and aircraft works could then be treated in this respect in the same way as other industrial premises.

(e) Industrial Premises

The CNL system should be rationalised to CNL (t) consistent with (a).

For distant premises, the index would be CNL_{dw} (t) based on spot or short-term L_{eq} readings taken downwind.

(f) All Other Sources

Same as (e).

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IRON FOUNDRIES AND NON-FERROUS MELTING

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In presenting this paper I hope to demonstrate not only the positive role local authorities have to play in the field of air pollution control but also the problems facing them. By adopting a critical appraisal of the problems it is inevitable that criticism will need to be levelled at all factions both within the production industries and the enforcement agencies. I make no apologies for this criticism but sincerely hope that it is of a constructive nature and will contribute to that end for which we are all surely working: the efficient operation of our manufacturing industries together with the maintenance and, hopefully, improvement of the living environment.

Whilst as early as the 15th Century the melting of metal featured in specialised activities, eg the manufacture of warfare weaponry, it was not until the middle and late 18th Century that this activity formed the basis for the industrialisation of the Country. The next two hundred years saw a massive expansion and continuation of these processes with scant regard to their effect on the environment. It now appears that whilst in recent times steps have been taken to protect the environment, a steady decline has also commenced in the manufacturing industries.

Figures produced by the Council of Ironfoundry Associations show that the production of ironcastings has fallen from 3.0 million tonnes in 1975 to 1.6 million tonnes in 1981, a fall of almost 50%. This declining trend has also been seen in the West Midlands area, particularly in that part known as the Black Country, where for more than a century the economy of the region was based on the "metal bashing" industries. The effects of the decline are well known, producing the modern scourge of unemployment. With the world wide recession and drop in demand for iron and steel it seems inevitable that this trend will continue unabated and it appears from recent statements made on behalf of the UK Government that future policies will be based on the new technological industries, not on propping up the old antiquated and inefficient technologies; this latter description having been applied to the metal melting industries.

What is interesting however is that whilst the industry has been in decline for the past 10 years, the problems of pollution from this source do not seem to have followed the same pattern. In discussion with colleagues in the West Midlands it appears that the recession has generated even greater problems with no immediate answers available.

The following factors are in my opinion the major reasons for this anomaly.

1. Lack of capital investment by the industry in new plant both for metal production and pollution control.
2. Lack of maintenance of existing production and pollution control plant.
3. Reluctance of Central Government to introduce suitable controlling legislation.
4. Lack of resources at local enforcement level to ensure regular checks and inspections.

Whilst I have set out these factors in what I consider to be an order of causative priority, none can be looked at in isolation as all of them are closely related.

The recession has also introduced new problems for Environmental Health Officers working in the field of pollution control in that the Planning Committees of local authorities are now faced with increasing pressures to allow industries which produce jobs, even at the price of adverse environmental effects. I think it is fair to say that, during the 1960s and early 1970s, in planning terms the jobs versus pollution argument was weighted in favour of the environmentalist and on many occasions applications were rejected on less than sound technical reasons. Today the pendulum has swung the other way and whilst the pressure for employment is great it has also meant that local authorities have had to carry out full environmental impact analysis of the proposals, thus enabling planning decisions to be made in the light of the full facts.

In order to understand the problems faced by local authorities it is necessary to look at the industries in some detail and the way in which controls are carried out.

FERROUS MELTING INDUSTRY

The control of iron foundry processes is divided, as in other fields of air pollution control, between HM Industrial Air Pollution Inspectorate (formerly HM Alkali and Clean Air Inspectorate) and the Environmental Health Departments of local authorities.

HMIAPI are responsible for:-

i) Cupolas using heated blast.
ii) Electric arc furnaces.
iii) Processes where oxygen or air enriched with oxygen is used to refine iron.

whereas the LA are responsible for:-

iv) Cold blast cupolas.
v) Electric induction furnaces.
vi) Rotary furnaces.

Whilst in essence the method of production of metal from any of the above sources does not vary significantly, the methods of control are totally different, a point I shall return to later in my paper.

FERROUS FOUNDRY PROCESS (Fig. 1).

In basic terms iron founding is the melting down of a mixture of scrap iron, pig iron, steel, coke and limestone, the coke providing the combustion media and support for the other materials and the limestone acting as a flux to remove unwanted impurities. The

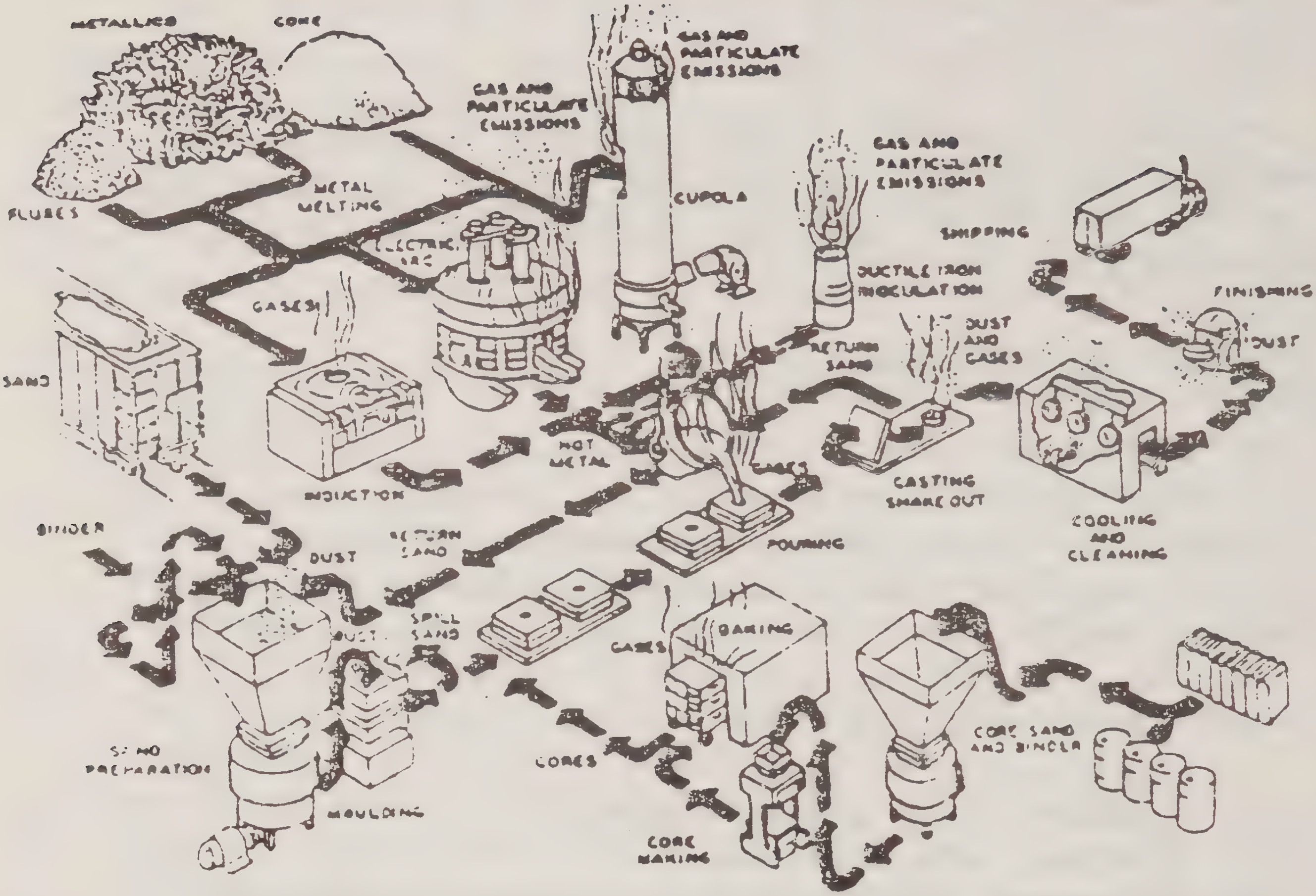


FIG. 1. DIAGRAMMATIC LAYOUT OF FOUNDRY

molten metal is then either tapped off into an independent holding furnace or into pots ready for pouring into prepared sand moulds.

After the metal has cooled in the moulds the resultant casting is knocked out either manually or on a vibrating table. It is then subjected to a shot blasting process to remove sand and dross and then passed to the grinding shop for final dressing. In many foundries this may be the final process, although in certain cases the finished casting may require some type of additional protective or decorative coating either by hand painting, dipping, spraying or fusion.

At each stage of the process the potential exists for significant emissions to atmosphere, either gaseous or particulate.

SOURCES OF EMISSIONS

RAW MATERIALS STOCKYARD

As well as the storage area for scrap iron, steel, pig iron, coke and limestone, many stockyards are also used for the collection of general waste, including metal returns, slags, spent foundry sand and dusts already collected by pollution control equipment. In older foundries the stockyard may also be the "knock-out" area.

All of the above activities have potential for severe dust nuisances and whilst there are no great technical difficulties in controlling emissions from this area, regular and efficient general housekeeping must be of the highest order. In particular the following steps should be taken:

1. Provision of covered bays for the storage of all materials.
2. Provision of concrete or similar hard standings to the floors of the bays.
3. Proper covered receptacles or bags for collected dusts.
4. Knockout to be carried out indoors, preferably in a proper extract-served area.
5. Quick cooling of slags.
6. Provision of mechanical means for cleaning concrete and road surfaces.
7. Sheeting of lorries, bringing or taking dusty loads to and from the premises.

LEGISLATION APPLICABLE

In all cases the most applicable legislation is section 92 Public Health Act 1936 as amended by Section 26 of the Local Government (Miscellaneous Provisions) Act 1982.

"any dust or effluvia caused by any trade, business, manufacture or process and being injurious, or likely to cause injury to the public health or a nuisance".

Environmental Health Officers who are well used to the use of Section 92 in all aspects of nuisance will also be well aware of the cumbersome procedures involved in applying this section. Nevertheless the recent amendment introduced under the Local Government

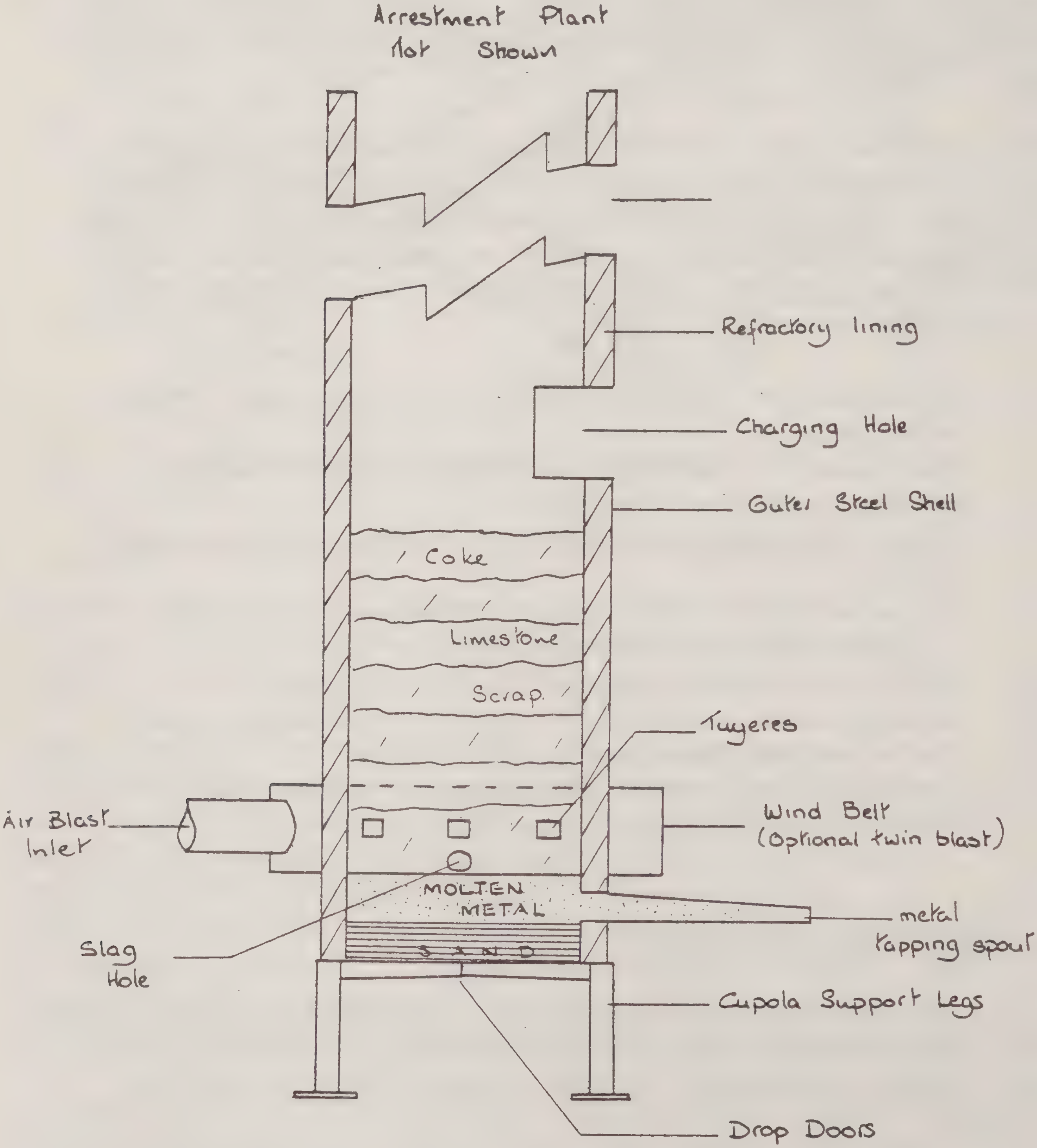


Fig. 2. COLD BLAST CUPOLA

(Miscellaneous Provisions) Act 1982 has removed the anomaly whereby the local authority were only able to act on behalf of inhabitants of the neighbourhood.

MELTING PLANT

Whilst the melting of the metal may take place in electric induction or rotary furnaces, the most common form of furnace used is still the cold blast cupola (Fig. 2). Emissions from this source are:-

a) Smoke

This arises from the use of scrap contaminated with oil, paint, rubber and plastics and subsequent failure to maintain a combustion flame in the upper part of the cupola shaft. Steps taken to prevent such emissions should include:-

i) Use of clean scrap.
ii) Suitable coke ratio. (Fig 3)
iii) Provision of an after-burner. (Fig. 3)
iv) Smokeless ignition.

Fig 3.

	Coke Charge		
	Below 11% (9:1 ratio)	11 - 14% (9:1 to 7:1)	Above 14% (7:1)
Spontaneous combustion above charge hole	No	Sometimes	Usually
Ability of afterburners to maintain combustion	Difficult	Usually	Always

LEGISLATION APPLICABLE

SECTION 3 CLEAN AIR ACT 1956

- "No furnace shall be installed in a building - unless

> it is so far as practicable capable of being operated continuously without emitting smoke".

SECTION 1 CLEAN AIR ACT 1956 IN CONJUNCTION WITH THE DARK SMOKE (PERMITTED PERIODS) REGULATIONS 1958

It is sometimes overlooked that the provisions of this section which limit the emissions of dark smoke from chimneys also apply to cupolas. Therefore, subject to the defences as set out in Section 1(3), there should be no more than 10 minutes of dark smoke in the aggregate in any period of 8 hours nor continuous emission exceeding 4 minutes for any cupola.

SECTION 16 CLEAN AIR ACT 1956

More often than not, the emissions from cupolas do not fall into the category of dark smoke but nevertheless cause nuisance by reason of odour etc. In such cases this section, which deals with 'smoke other than dark smoke emitted from a chimney of a building or from a chimney serving the furnace of a boiler or industrial plant attached to a building', may be used. Unfortunately, the procedure to be adopted is that for the purposes of Part III of the Public Health Act 1936 and some limitation may be imposed by the exemptions for smelting works as set out in Section 109 of the Act.

b) Grit and Dust

There is no doubt that the emission of grit and dust from the cupola is a major environmental pollutant albeit, because of the density of the particles emitted, a local one. It is estimated that for every ton of metal melted the corresponding emission of particulate matter will vary from 10-50 lbs.

A recent study in the West Midlands estimated that the emissions of grit and dust from cupolas in this area amounted to some 1400 tonnes per year. Corresponding work carried out by one of the Metropolitan Boroughs in the Black Country estimated that the emissions from the

21 foundries in that authority amounted to 450 tonnes per year. It is likely, in the case of the former, that this figure is extremely conservative in that the assumption was made that all foundries complied with the proposed emission rates as laid out in the Draft Clean Air (Emission of Grit and Dust from furnaces) Regulations, an assumption which is unlikely to be correct.

Sources of this grit and dust from the cupola are:-

1) General dirt and dust from the scrap metal.
ii) Sand attached to metal returns.
iii) Breaking up of the metallurgical coke.
iv) Breaking up of the limestone flux.

- all of which is aggravated by the action of blowing air upwards through the cupola and the method of drop-charging the cupola.

Whilst it may be possible to reduce grit and dust by a careful watch on the scrap and its handling, the practical answer adopted by the industry is arrestment of it in the exhaust gases.

PENTHOUSE (Fig 4) (very few now exist)

This is simply an expansion building into which the cupola gases discharge. It will only settle out

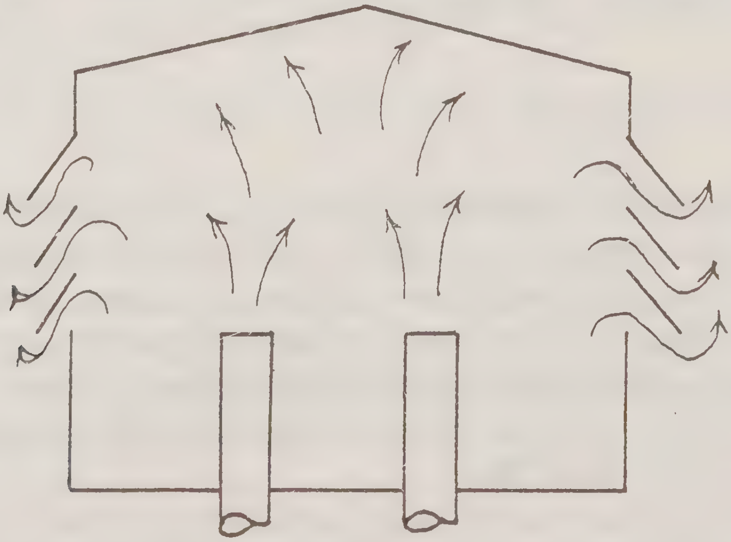


Fig. 4. PENTHOUSE

particles in excess of 150 microns and has an efficiency of approximately 20%. Apart from its low efficiency it has the added disadvantage of slowing down the gases, resulting in a quicker fall to ground level and giving rise to local complaints.

SIMPLE DRY ARRESTER (Spark Arrester) (Fig 5)

This can still be found in wide use on small cupolas throughout the country, and relies once again on expansion and deflection. As with the penthouse it will only settle out large particles and has an approximate efficiency of 10-15%.

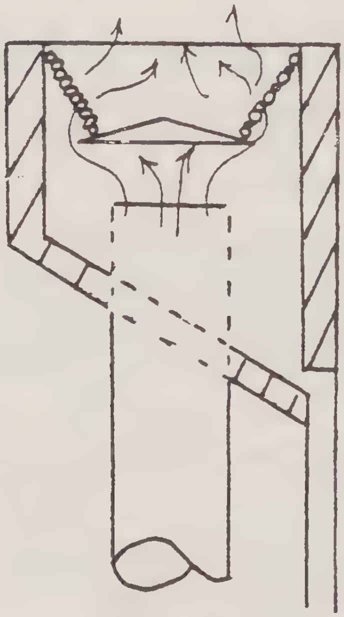


Fig. 5. SIMPLE DRY ARRESTER

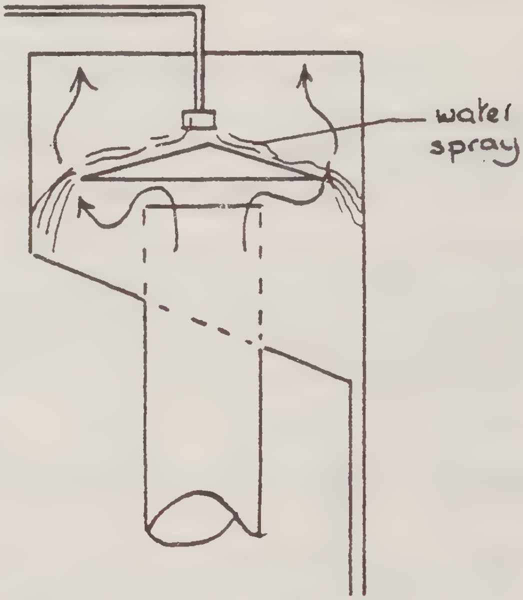


Fig. 6. WET ARRESTER

SIMPLE WET ARRESTER (Fig 6)

This is the most common form of arrestment plant used in the foundry industry (88% in the West Midlands). It is an extension of the dry system in that water is sprayed over the dome at the top of the cupola creating a water curtain through which the gases must pass. It will remove fairly coarse dusts down to 50 microns and has an efficiency of 50-60%.

This simple system has a number of advantages including low energy running costs, ability to handle hot gases

(1300°C) without additional cooling plant, and the absorption of $\frac{1}{3}$ to $\frac{1}{2}$ of the sulphur dioxide emission.

Against this, however, must be weighed the disadvantages of: the need to carry out neutralisation of the water to prevent corrosion; creation of a wet, cool emission resulting in poor dispersal; and the disposal of liquid and sludges high in heavy metals.

It is important during inspections of foundries to carry out an inspection of the arrestment plant at the top of the cupola although, because of health and safety risks due to possible carbon monoxide emissions, this may have to be carried out during plant shut down, usually on a Saturday morning. Common faults found during such inspections are:-

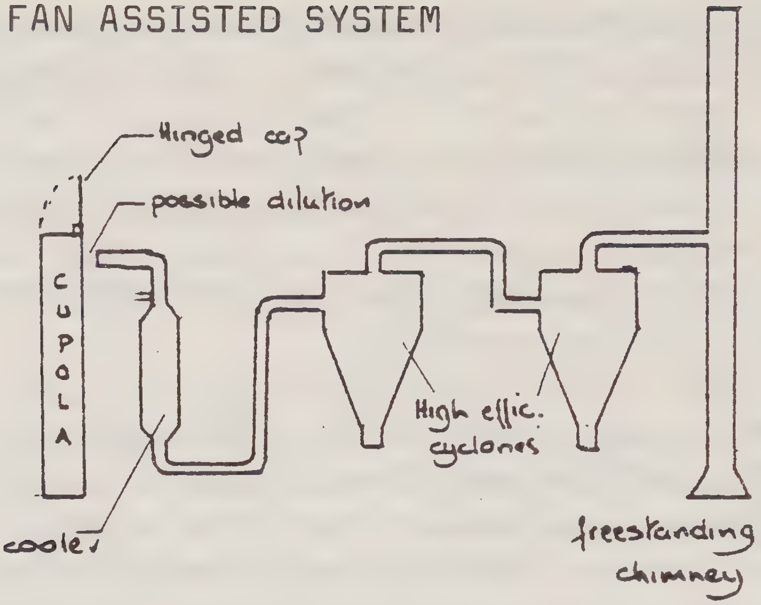
i) Deflector dome missing altogether!! (dry arrester systems)
ii) Distortion of the dome, leading to irregular water curtain.
iii) Build up of grit and dust on top of the dome, once again leading to irregular water curtain. This appears to be more prevalent where chimneys have been installed after the arresters.
iv) Partially blocked water rose, giving rise to irregular water curtain.
v) Insufficient water pressure to give the required water coverage over the dome.

FAN ASSISTED SYSTEM (Fig 7)

During the early 1970s, with the proposals for the new grit and dust regulations, new more efficient systems of collection were devised based on fan assistance. The first of these was the FTL/Barnes Cool Cap designed in Canada with a similar plant produced in this country by E.A. Roper and Co Ltd.

Efficiencies claimed for these plants are around 80% for particles down to 5 microns with overall efficiencies of 85 to 90%.

Fig. 7. FAN ASSISTED SYSTEM



The main advantage of these systems over the wet arrester, apart from the increased efficiency, is the elimination of the cool wet plume and associated poor dispersal characteristics. Against this, however, must be weighed the increased energy running costs and in some cases noise problems from the fans.

Unfortunately the reluctance of Central Government to introduce the new Regulations, coupled with the general recession, has meant that the installation of this type of plant has not proceeded on the scale originally anticipated.

HIGH PRESSURE SCRUBBERS (Fig 8)

For the reasons stated above very few foundries have invested in this type of equipment. Of those who have, most have opted for the venturi scrubber type which, whilst capable of removing particles down to fume with overall efficiencies in excess of 95%, has proved expensive to run and requires extensive maintenance.

Whilst in principle it is also possible to apply other high efficiency cleaning plants i.e. bag filters and electrostatic precipitators to cold blast cupola emissions, in practice in the UK this has not occurred. It is likely therefore that, unless there is an unexpected up-turn in the trade or new legislation is introduced, the lower efficiency units as mentioned above will continue to be the norm.

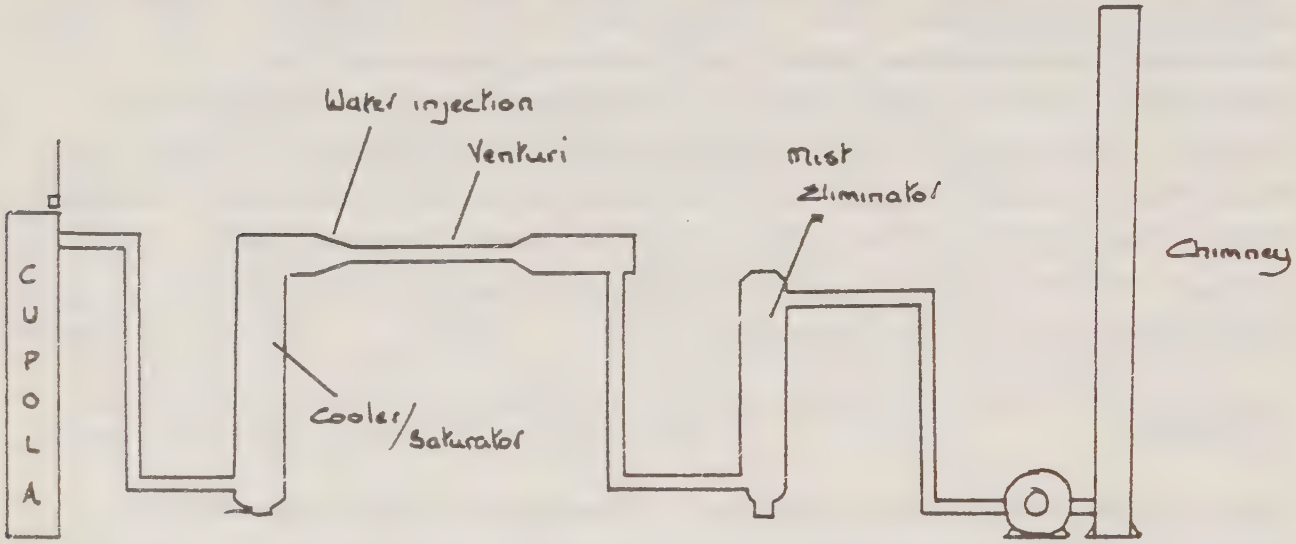


Fig. 8. HIGH PRESSURE SCRUBBER

LEGISLATION AVAILABLE

As mentioned previously it was hoped that following the Report of the Second Working Party on Grit and Dust Emissions regulations would be made under Section 2(1) of the Clean Air Act 1968. This was not to be, therefore controls are limited to:-

SECTION 6 CLEAN AIR ACT 1956
SECTION 3 CLEAN AIR ACT 1968

These sections require that no furnace shall be used in a building unless the furnace is provided with plant for arresting grit and dust which has been approved by the local authority and such plant must be properly maintained and used.

Section 7 of the 1956 Clean Air Act and Section 5 of the 1968 Clean Air Act enable the local authority to require the measurement of grit and dust from furnaces; however, in the light of the lack of emission levels in relation to cupolas this would seem to be a pointless exercise.

The only other guidance open to local authorities is the document produced by The Ministry of Housing and Local

Government in 1968: "Cold Blast Cupolas." This states that simple wet arresters should be used wherever possible; but as a guide dry arresters may be accepted on cupolas melting 3 tons per hour and operating up to 250 hours per annum and wet arresters should be required for cupolas melting above 5 tons per hour and operating 500 hours per annum or more. Between these two limits the choice of arrester equipment should be resolved by discussion between the local authority and the foundry.

c) Fume

Fume is normally defined as air-borne solid matter smaller than one micron and is a constituent of cupola emissions. It is difficult to generalise about the type and amount of fume emitted from the cold blast cupola as this will depend upon many factors such as the use of highly contaminated scrap, high proportions of steel scrap and the use of oxygen in excess of 3%.

It is estimated by Simmons of JURUE, Aston University, that fume emissions in the West Midlands are equivalent to the emission of grit and dust i.e. 1400 tonnes per year. Such emissions, as with grit and dust, contain heavy metals; but whereas with grit and dust, particle sizes are such that they are outside the respirable range and fall out locally, with fume they can be taken into the respiratory system with dispersal over much wider distances.

Concern is now being shown by West Midlands authorities as to the effect these emissions are also having on the soil levels throughout the region; typical levels are shown (Fig 9) for proposed housing sites close to iron foundries.

Means available to local authorities to control fume are extremely limited as collection can only be effective with high efficiency plant such as bag-filters, electrostatic precipitators and high energy scrubbers. For

Fig 9

Mg/Kg

Metal	Site A		Site B		Recommended Levels*	
	Total	Available	Total	Available	Total	Available
Lead	720-1450	360-1050	770-1820	2-25	550	-
Copper	95-130	30-45	70-230	13-16	-	140
Chromium	40-80	0.1-1.0	20-110	2	600	
Cadmium	1-2	0.4-0.9	4-12	0.8-3	5	-
Zinc	520-1050	120-250	670-6020	220-2440	-	280
Nickel	65-90	4-10	90-250	16-35	-	35

* Tentative Guidelines for Acceptable Concentrations of Certain Trace Elements in soil DOE ICRCL 38/80 (R) - March 1981

reasons stated previously these means of control are not at present acceptable to the industry. Accordingly the LA is left with the less than satisfactory answer of dispersal via tall chimneys. Even so with the guidance currently available this is difficult. The 1968 Ministry of Housing and Local Government document, "Cold Blast Cupolas", recommends that cupolas should be fitted with chimneys in accordance with the Chimney Heights Memorandum but should never be less than 65 feet. In the case of fume problems it recommends that arrestment should be considered first but if this is impracticable then the chimney height should be increased to 120 feet or more.

One local authority in the West Midlands area has adopted a 'tall chimney' approach to cupolas where fume has been found to be a problem. That authority is satisfied that the policy has been successful; however it is a policy not readily acceptable to the industry.

d) Sulphur Dioxide

As sulphur dioxide is one of the major parameters by which national air pollution levels are measured, any process emitting this pollutant must be controlled. The foundry process is no different and control is effected with the policy of dispersal. Cupola heights are calculated in accordance with the Chimney Heights

Memorandum based initially on a sulphur content for metallurgical coke of 0.7%, but with compensating allowances having to be made for 50% absorption of the sulphur during the melting process and a further 30-50% absorbed if a wet system of grit and dust arrestment is installed.

LEGISLATION AVAILABLE

Section 6 Clean Air Act 1968.

POURING AND KNOCKOUT

When molten metal is poured into the mould smoke and fume is given off. The amount will depend upon the type of sand, amount of coal dust or pitch and the type of cores used.

In many small unmechanised foundries the pouring process takes place on the foundry floor and the resultant smoke and fumes are left to escape through windows and roofs. However in the larger modern foundries pouring is carried out on mechanised lines which are hooded and ducted to a suitable extract point.

Treatment of this extract, whilst technically possible using thermal destruction, is uneconomic due to the vast quantities of air dilution occurring. Accordingly the standard practice is dispersal via a tall chimney.

The knockout area is an extremely hot and dusty environment and to protect the operators is normally served by an extract system. However as well as extracting heat the system will also extract fume, sand and metal dust which, if not treated, will give rise to emissions which may amount to a nuisance.

Collection is normally by a low pressure water spray type system which if properly maintained can be extremely effective. (Bag systems are not recommended as the moisture in the extracted gases can lead to blocking of the filter medium.)

Particular points to be noted on this type of filter are:-

i) May freeze up in winter.
ii) Spray nozzles become blocked.
iii) Water levels not maintained at correct position.
iv) Failure of ancillary sludge removal equipment.

LEGISLATION AVAILABLE

SECTION 16 CLEAN AIR ACT 1956

With regard to smoke from pouring, the nuisance provisions relating to smoke other than dark smoke from a chimney may be applied.

SECTION 92 PUBLIC HEALTH ACT 1936

Dust and sand emissions from the knockout area can be defined as any dust or effluvia for the purpose of nuisance action under this Section.

SHOT BLASTING AND GRINDING

The removal of sand and dross from the knocked out castings is carried out in shot blasting cabinets. In these metal shot is blasted against the surfaces of the castings with the resultant removal of the sand and dross. Air extracted from the cabinets contains sand, broken shot and iron particles and without filtration will undoubtedly lead to a nuisance situation. The most satisfactory method of collection is bag filters although on occasions cyclone collectors have been used. The efficiency of the latter however is nowhere near that of the former.

Emissions from the grinding process are similar to those arising from the shot blasting process and in both cases will give rise to the common problem of the orange sand paper effect on the paintwork of cars. Collection of particles should once again be with bag filters. It is interesting to note that many complaints of alleged nuisance from the cupola do in fact arise from this source and regular checks of the filters should form an integral part of foundry inspections, with particular reference to split or displaced bags.

On a number of occasions it has also been found that top extracts to grinding wheels have been ducted direct to the external air even though the bottom ones are ducted to filtration equipment.

LEGISLATION AVAILABLE

In both cases the nuisance provisions of Section 92 of the Public Health Act 1936 will apply.

Section 10 of the Clean Air Act 1956 can still be used where plans are submitted for the installation of ducts to serve these processes.

COREMAKING

The traditional method of making cores for the moulds, using silica sand mixed with binders such as linseed oil and subsequent baking in an oven, has always led to problems of odour and on some occasions smoke. Theoretically the odour can be eliminated by incineration of the resultant gas at approx. 850°C; however, the limiting factor has once again been the energy running costs of this incineration. Accordingly, dispersal via a chimney is still the norm for this process.

The same principles apply to shell and hot box cores but here the running costs are even more prohibitive due to the diluting air extracted by the necessary hooding. Some improvements have been effected however by new processes such as CO2 injection and the use of chemical resins which react at air temperatures, thereby obviating the baking process.

LEGISLATION AVAILABLE

If smoke is considered to be part of the emission from the chimney, extract ducting or the building itself, then Section 16 of the Clean Air Act 1956 can be utilised.

If the problem is one merely of odour then the term 'effluvia' as defined in Section 92 of the Public Health Act 1936 may well bring the problem into this category.

NON FERROUS MELTING

Whilst the principles involved in ferrous and non-ferrous melting are not dissimilar, the problems as far as local authorities are concerned are much less in the case of the latter.

The reason for this is that the major part of the non-ferrous industry is, under the Health and Safety (Emissions into the Atmosphere) Regulations 1983, carried on at Registered Premises (formerly alkali or scheduled works under the Alkali and Works Regulation Act 1906.)

Nevertheless Local Authorities do have responsibilities in this field at premises where non-ferrous metals are melted without producing noxious or offensive gases or, in the case of certain metals, without producing dust or fume. The most common metals involved are aluminium, zinc and brass.

The melting process in most cases takes place in small pot or bale-out furnaces which may be fired by gas, 35 seconds gas oil, or electricity, the only emissions being the products of combustion of the fuel and some oxide fume when the metal reaches temperature. However in some cases where contaminated scrap may be used smoke emissions may also occur. Typical examples of this are in the recovering of aluminium in sloping hearth iron/aluminium furnaces (Fig 10).

This type of furnace is commonly found in scrapyards and is normally operated under less than ideal conditions. The raw material or stock is invariably car engine blocks and parts which are generally contaminated with used engine oil. The main chamber of the furnace may have 1-4 oil or gas fired burners with a secondary after burning chamber having 1-2 oil or gas fired burners. In nearly all cases the burners are simple hand operated jets.

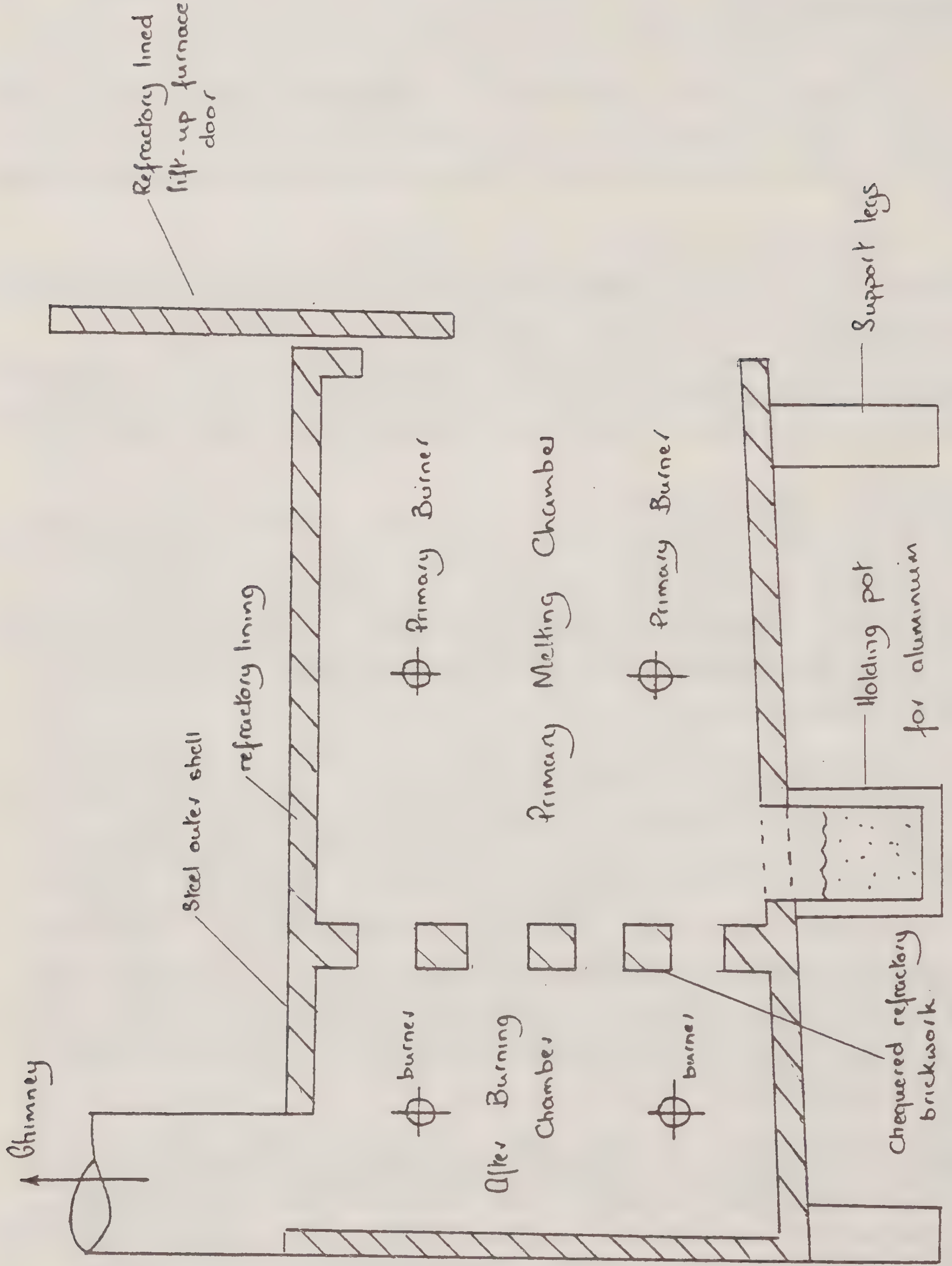


Fig. 10. Sloping Hearth Aluminium Recovery Furnace (Irony - Aluminium)

Typical causes of smoke emission are:-

i) Starting up from cold

Ideally before charging the furnace the refractory lining should be heated and loading of the furnace progressively increased. In practice, in order to reduce costs the furnace is charged cold and then the burners are lit.

ii) Overloading of the furnace

If this primary chamber is overloaded cooling of the burner flame takes place as a result of impingement onto the cold metal surfaces. Likewise insufficient temperature can be maintained in this chamber to ensure efficient combustion.

iii) Poor Burner Control

In order to carry out efficient melting of the aluminium there must be continual adjustment of the burners. This is rarely done: once the burners are lit then the setting is left unadjusted until the end of the melt.

iv) Operation with the door open

Lack of maintenance of the refractory lining to the furnace door may lead to distortion, causing difficulty in operation. In this case the operator will leave the door in the open position thereby admitting excess secondary air, causing cooling of the furnace.

v) Operation without the after burner

Except towards the end of the melting cycle it is virtually impossible to achieve complete combustion in the primary chamber. Once again as a cost saving exercise, the temptation is to save oil by not using the after-burners.

Grit and dust emissions are not normally seen as a problem from this type of furnace; however during the emptying of the residue from the furnace, normally by raking out, severe dust nuisance can occur. This can be controlled much more easily if the furnace is situated within a building where the dust can be contained, although in many cases furnaces are freestanding in an open yard.

LEGISLATION AVAILABLE

SECTION 1 CLEAN AIR ACT 1956

With regard to dark smoke emissions from the chimney, subject to the exemption under Section 1(3), the limits as specified by the Dark Smoke (Permitted Periods) Regulations 1958 will apply.

SECTION 16 CLEAN AIR ACT 1956

In cases where smoke may not be dark but still creates a nuisance, the nuisance procedure as set out in this section will apply.

SECTION 92 PUBLIC HEALTH ACT 1936

Where dust problems as outlined above occur the 'dust or effluvia' interpretation will apply to this type of nuisance.

SECTION 3 CLEAN AIR ACT 1956

Section 3 requires that no furnace shall be installed - on any land - unless it is so far as practicable capable of being operated continuously without emitting smoke. The requirement for afterburning facilities can be related to this Section.

SECTION 6 CLEAN AIR ACT 1968

The height of the chimney to serve the furnace should be calculated in accordance with the Chimney Heights Memorandum based on the total consumption of oil by all the burners, including the afterburners. It may also be necessary to estimate the amount of oil contamination that occurs from engine blocks and add this figure to the known consumption.

GALVANISING

Galvanising is a process for applying a coating of zinc to iron and steel by dipping it after preparation into molten zinc.

Zinc coatings can be applied by other means i.e. spraying, plating, sherardising and using zinc dust paints, but these do not fall within the current discussion.

The process falls into two main parts, a) preparation and b) hot dipping.

PREPARATION

Before galvanising, steel must be degreased to remove grease, oil, paint or preservatives. This is done by immersion in a suitable solvent, i.e. trichloroethylene, followed by pickling in a 14% solution of hydrochloric acid. In both cases it is normal to extract off both degreasing and pickling baths with extract ducting above roof eaves level. In some circumstances it may also be necessary in the case of acid mist carry-over to provide a scrubber to remove this.

Where steel has welding slag, heavy rust or old paint on the surface, and cast iron is to be galvanised or when an extra thick coating is required, shot blasting is carried out prior to pickling. Extract from the shot-blasting cabinet should, as in the foundry industry, be taken through a suitable filter unit i.e. bag filter.

HOT DIPPING

Molton zinc is maintained in a heated bath at a temperature of between 445° - 465°C with a surface coating of ammonium chloride flux. The article to be galvanised is then immersed in the bath through the flux, care having been taken to ensure that all moisture has been eliminated following the pickling procedure. Failure to do so results in sometimes dramatic explosions and subsequent flying of the molten zinc into the work area.

As the article is removed from the bath additional ammonium chloride flux is added to it to remove dross and ensure a 'clean' finish. Problems that arise during the dipping process are related to this use of the ammonium chloride flux.

During the immersion of the article into the bath dense clouds of ammonium chloride fume are emitted, this being collected via lip type extracts at the rear of the bath. The distance from the furthest point of the bath to the extract is critical and should not normally exceed 5 feet. At distances greater than this it is difficult to collect all the fume during heavy emissions; attempts to overcome the problem by increasing extract velocities result in the flux being drawn off the surface of the bath in particle form.

Additional fume is also created during removal of the article from the bath when the flux is added. Traditionally this was carried out by the operator hand-dosing the ammonium chloride; however it has been found that by the use of compressed air guns the flux can be directed more accurately onto the article with a resultant 50% saving in ammonium chloride.

Various methods have been tried to collect the fume including scrubbing and bag filters; however, because of the range of particle sizes and the extremely hygroscopic nature of the fume, no one method has yet been accepted by the industry. Instead the norm is the use of over-size ducts and expansion chambers to settle out larger particles with ultimate dispersal of the fume at a minimum height of 150 feet.

LEGISLATION AVAILABLE

The galvanising industry is a typical example of the problems facing local authorities in air pollution control in that all of the problem areas must be assessed in terms of nuisance with the attendant procedures associated with this approach. Although, as stated previously, in the case of new installations heavy reliance is place upon conditions attached to planning consents.

HEAVY METALS

Whilst it is highly likely that the large metal refiners etc. which are registered are the major contributors to air-borne levels and subsequent ground level contamination, local sources under the control of the local authority can still produce problems and care should still be taken when developing residential areas close to such sources. The following table shows details of soil analysis from a proposed housing site adjacent to a former small zinc and aluminium melting factory in the West Midlands area.

	Soil Sample		Recommended Level *	
Metal	Total	Available	Total	Available
	Mg/Kg		Mg/Kg	
Lead	100-990	25-620	550	-
Copper	100-8650	35-3000	-	140
Zinc	320-126,000	90-21000	-	280
Cadmium	2-150	0.7-70	5	-
Chromium	16-1600	2-11	600	-
Nickel	45-3400	4-1050	-	35

* Tentative Guidelines For Acceptable Concentrations of Certain Trace Elements in Soil DOE ICRCL 38/80 (R) - March 1981

DISCUSSION AND CONCLUSIONS

This paper is presented under the general theme "Environmental Problems Associated with the Smaller Industries". Unfortunately even this heading tends to convey the misleading impression that local authorities are only concerned with minor sources of pollution and therefore their resources, expertise and methods of control are insignificant compared to those required to control emission from the apparently "larger industries" - a view, as I have stated many times publicly, which seems to be held by certain Central Government Departments.

The following statement is taken from a memorandum attached to the Draft EEC Directive on Combatting Air Pollution from Industrial Plants:

"this is not primarily a matter which would be of concern to local authorities but we feel that there may be some interest/involvement at local level".

Delegates should be aware that this Directive is intended to implement a series of measures and procedures designed to prevent and reduce air pollution from stationary industrial plants within the Community. It seeks to harmonise standards throughout the member states and will apply in the main to premises controlled in this country by HMIAPI although the list of proposed plant does include foundries with a melting installation in excess of 5 tonnes per unit, and slaughterhouses.

In addition to industrial plant the Directive seeks to reduce emissions of specific pollutants including heavy metals and metal compounds.

Whilst it is accepted that the enforcement role in the majority of the installations will rest with HMIAPI, nevertheless LAs have a right to be consulted on matters which affect the environment for which they are responsible.

In addition the monitoring of effects of any controls at source has, in this country, always been carried out most effectively by the LAs. It is worthwhile considering whether the combined emission of pollutants from 33 foundries in one authority area is any less significant than the emission from 1 registered premises within that same authority. I would obviously suggest that it is not; however the tools that local authorities possess to control emissions from their premises are infinitely less than HMIAPI have in the case of registered premises.

As can be seen from the paper time and time again the LA is required to prove nuisance under the provisions of the Public Health Act 1936, a decision which is extremely subjective and difficult to define. I know from experience that many local authorities have, despite this handicap, attempted to control emissions from premises under their control (foundries being a typical example), by the introduction of a system of routine industrial inspections. During these inspections pollution producing plant and associated control equipment is checked to ensure it is operating at maximum efficiency and, where necessary, steps recommended to carry out remedial work.

By adopting this approach it is possible to foresee a significant number of major breakdowns which may result in severe pollution episodes, a situation which is becoming all too common as companies cut down on routine maintenance as part of economies to fight the current recession.

Prior to local government reorganisation in 1974 criticism was often levelled at local authorities that they lacked the expertise and resources to cope with air pollution problems and in some cases this criticism may well have been justified. Since 1974 however, I would suggest that the majority of local authorities, particularly those in the large connurbations where the problems exist, have developed the organisational facilities and resources to deal with a far wider range of pollution than previously thought possible. Unfortunately lack of recognition of this fact, coupled with the failure of Government to introduce enabling legislation, has meant that the true potential of local authorities in air pollution control has yet to be realised.

It is hoped however that, through its involvement with organisations such as the National Society for Clean Air and the promised review of legislation in the Government's Response to the Fifth Report of the Royal Commission, this recognition and potential will finally be achieved. In practical terms, therefore, I hope eventually to see a system of unified air pollution control based on a concept of prior consents, or registration with best practicable means, being defined for a much wider range of industries including those controlled by local authorities.

With regard to enforcement roles I do not foresee any major difficulties in HMIAPI will retain control over difficult processes, particularly in the chemical industry; although I see no reason against an extension of the LA's involvement into some existing registered works, perhaps on an agency basis as suggested in the Fifth Report.

This change is not likely to be achieved overnight and no doubt voices of opposition will be raised in all quarters; however I am convinced that if local authorities are to fulfil their role as guardians of the environment in its widest sense, protecting both the needs and interests of the residents and industry, then such an approach is inevitable.

ACKNOWLEDGEMENTS

I would like to convey my special thanks to Mr. S.W. Hogg, Director of Environmental Health, and C.C. Brookfield, Divisional Environmental Health Officer, Sandwell Metropolitan Borough Council, and to Mr. G. Brownsword, Divisional Environmental Health Officer, Dudley Metropolitan Borough Council, for their valuable help and information supplied.

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SCRAPYARDS AND THE RECOVERY OF METALS FROM WASTE MATERIALS

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My paper covers a number of points which will be only too familiar to those Environmental Health Officers dealing with air pollution and noise control matters, particularly those officers in the heavy industrial areas where the iron and steel industries predominate. The environmental problems associated with scrapyards are not those which make the headlines in the national newspapers or the technical journals; nevertheless, despite the legislation available to deal with them, they can cause longstanding misery to local residents from smoke, fume, dust, noise and land contamination. There may even be asbestos on old boiler plant which, as research in the USA has shown, can be hazardous to the health of employees of both scrapyards and foundries.

Improvements in cupola technology over the past ten years, such as twin-blast air supply and oxygen enrichment, have enabled foundries to increase the ratio of scrap to pig iron from 4:1 to 12:1. With scrap iron costing only one third of the price of pig iron, this has effected considerable savings in the cost of raw materials. However, research by Simmons[1] of the University of Aston on foundries in the West Midlands has shown that, although the recent decline in overall production of iron castings has produced a similar decline in grit and dust emissions, this will not have been the case for metal emissions because of the increase in the use of scrap.

In 1982 some 7 million tons of scrap iron and steel were sold by British scrap dealers to foundries and steel works in this country and abroad.

The iron foundry industry in this country requires large quantities of clean scrap iron and steel: 'clean' in that it should be free, as far as possible, from oil and grease and other dirt, and free from other metals which can have disastrous consequences upon the quality of finished castings. The presence of oily scrap in cupolas and electric furnaces inevitably produces smoke. In addition, some cutting fluids contain sulphur compounds, and when borings coated with these materials are charged into the furnace, sulphur dioxide is generated by combustion. This is absorbed by the water in the gas cleaning equipment giving rise to acidic conditions and potentially high rates of corrosion. In the case of electric furnaces, where fabric filters may be used for the collection of particulate matter, oil vapour can condense, making it impossible to clean the filter media.[2]

The most serious metallic contaminants in iron foundry scrap are lead, aluminium and chromium. In electric furnaces lead is largely retained in the molten metal, but to a lesser degree in cupolas. The presence of lead can have a catastrophic effect upon flake graphite iron in amounts as low as 0.0003% and its presence in grey cast iron can cause a remarkable drop in tensile strength, resistance to impact and resistance to thermal shock. Lead can be introduced in scrap containing lead based paint, vitreous enamelled scrap, lead bearing fluxes such as fluorspar and leaded steel scrap. It is possible that a foundry which has produced castings contaminated with lead, and which has eliminated the source may find that the problem persists due to the absorption of lead into the furnace of ladle linings.[3]

Aluminium is another contaminant which can have serious effects upon iron castings, if present, at levels above about 0.005%. The contaminated iron, when in contact with moisture from the surfaces of green sand moulds, readily dissolves hydrogen which separates to form pinholes on solidification of the iron[4]. At this level aluminium can also cause realignment of the graphite nodules. Serious reduction in the tensile strength of the castings results in both cases[5].

Chromium, which is found in stainless iron or steel scrap, promotes the formation of "chill" (white iron) in levels above 0.2% in grey iron castings. The presence of "chill" at free edges of castings increases the risk of cracking. Sulphur is also a potent "chill" forming element[6].

Research by C.W. Pompeii[7] at the University of Youngstown, Ohio, U.S.A. has shown that health hazards due to excessive exposure to lead fume can occur in iron foundries using electric induction furnaces for melting scrap contaminated with lead. Lead is absorbed into the blood by inhalation of lead fume, and by ingestion, for example, of lead-bearing dust on the hands. Pompeii has concluded that petrol engine scrap has largely been overlooked as a source of lead and that ventilation hoods should be provided on furnaces in foundries and for ladles during skimming to prevent excessive exposure to lead.

His research also revealed that scrapyard workers were exposed to excessive levels of lead. The scrapyard he studied used a crusher to break the engines down into smaller pieces, which were then passed through a caustic bath to remove oil and grease, then onto a sorting table, where employees using oxy-acetylene torches removed connecting rods and rocker box covers from engine heads. No employee was provided with local exhaust ventilation. Samples for lead were taken in the breathing zones of the employees and the results are shown in Table 1 below.

TABLE 1 Lead exposure of scrap processing employees determined by personal sampling devices. Figures are in mg/m^3

Operation		Exposure	TLV
Test 1	Con rod burner	0.936	0.15
	Cover burner	0.719	0.15
Test 2	Con rod burner	0.351	0.15
	Cover burner	0.260	0.15

* TLV (Threshold Level Value) refers to airborne concentrations of substances to which it is believed nearly all workers may be repeatedly exposed without adverse effects. Because of wide variations in individual susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations at or below the TLV. (Pompeii Modern Casting 1979 Vol. 69 No. 4)(amended)

Lead is an element of both brass and bronze and obvious sources of lead would have been flashings on bearings and pistons; if the employees had been cutting these, then the lead exposures which were discovered would have been expected. Pompeii observed that this was not the case and an alternative source of lead had to be found. The "overlooked" source of lead appears to have been the leaded petrol used in the engines. Lead is added to petrol in the form of lead alkyl compounds, tetraethyl lead and tetramethyl lead as anti-knock ingredients. During combustion they are mixed with chlorinated or brominated hydrocarbons in sufficient quantities to convert the lead into inorganic halogen salts which accumulate on the piston head and cylinder walls. The piston rings remove excess accumulations from the walls and oil brought up by the rings carries the deposits into the crank case. Lead salts then accumulate on any engine parts submerged in this contaminated oil. When engine parts are washed in the caustic bath, the oil is removed but not the lead salts; and as these are cut up, heat from the oxyacetylene torches volatises the lead salts, generating lead fume. To confirm this source of lead, Pompeii took from the sorting table at the scrapyard, a random sample of parts from engines using leaded petrol and soaked them for 30 minutes in a 20% solution of nitric acid to leach out any lead. His results, shown in Table 2, indicated that leaded petrol, when burned in an internal combustion engine, formed diethyl and triethyl lead salts and lead hydroxide.

Pompeii recommends that, in order to eliminate this source of lead exposure, the engine parts should be treated with caustic solutions to remove oil and grease, then be washed in an acid bath to leach out the lead before being sorted and cut up. In my experience in this country, any pretreatment of vehicle engines at scrapyards prior to their being cut up with oxyacetylene torches is extremely rare. Cutting up is usually done on the ground with the men bending over the engines. As the fume rises, not only are the men exposed to any lead which may be volatised, but to any other contaminants contained in the oil. Pompeii's research extended to the foundrymen who would receive the scrap and some of his results are shown in Table 3.

TABLE 2. Lead found on random samples from a scrap sorting table.

Location	Amount (mg)
Cylinder wall (1)	0.46
Cylinder wall (2)	0.38
Con rod (1)	0.48
Con rod (2)	0.52
Piston head	3.70
Deposit on piston	14.71

(Pompeii Modern Casting 1979 Vol. 69 No. 4)

TABLE 3 Lead exposure of two foundrymen. Figures are in mg/m^3

Operation	Exposure	TLV
Scrap A		
Test 1		
Furnace charger	0.440	0.15
Furnace operator	0.530	0.15
Test 2		
Furnace charger	0.757	0.15
Furnace operator	0.433	0.15
Scrap B		
Furnace charger	0.330	0.15
Furnace operator	0.215	0.15

(Pompeii: Modern Casting 1979 Vol. 69 No. 4)(amended)

The foundry employees who were tested would take approximately 5000 pounds of scrap, preheated to 1000 deg. F, and transfer it to the furnaces in a container. The empty container was then returned to the charging area to be refilled and this operation was repeated every half hour. I should be pleased to know whether any similar work has been done in this country either by the Health and Safety Executive or as an academic exercise. My own experience of excessively high blood lead levels is limited to a scrap yard, which specialised in breaking up and recovering lead from vehicle batteries, which at the same site also gave rise to serious land and river contamination problems.

The need to provide relatively clean scrap for iron foundries is, therefore, essential and the responsibility for doing so in the majority of cases rests with the scrap dealers, their contracts with the foundries making this a prerequisite. Whilst the scrap metal trade makes a valuable contribution to the economy, not only by providing a cheap feedstock, but also by recycling finite materials, the cost of providing sophisticated equipment for the cleaning of contaminated metal is, in the majority of yards and particularly the smaller ones, beyond their resources. Nevertheless, most yards continue to attempt to clean their scrap by alternative means, and the methods adopted are those which give rise to the environmental problems encountered daily by the Environmental Health Officers in the West Midlands.

The scrap dealers in the West Midlands fall roughly into three categories:

1. The 'tatters', some itinerant, others with tiny back street premises, who roam the streets with a lorry, or in some cases still, a horse and cart, and who at the end of the day, sell what they have managed to scavenge to a dealer.

2. Small dealers, concentrating on vehicle scrap, cutting up engines and car bodies with, in some cases, a furnace for recovery of aluminium.

3. Larger yards, handling all types of ferrous scrap, aluminium, brass, zinc and copper, and including such plant as furnaces, vehicle crushers, balers, fragmentisers, mechanical grabs, bulldozers and briquetting facilities.

All three types of scrap merchant are encountered within my own Authority of Sandwell which has 80 scrapyards licensed under the Scrap Metal Dealers Act, 1964, serving the 27 remaining iron foundries in the Borough.

The origins of many of the yards go back to the last century and several can be seen on the old Ordnance Survey maps as rag and bone yards. However, the nature of the activities at these yards, particularly over the last twenty years, has changed dramatically; changes which have led in the main to many of the problems which are encountered by Environmental Health Officers. What may have commenced as a small family business, at the back of a house or in a small field, collecting rags and some metal, may now have become a highly mechanised business working throughout the night, with the inevitable air pollution and noise problems, and in many cases without the need to refer to the local planning authority in order to do so. The problems are, of course, exacerbated if, as in many cases in the West Midlands, residential development has also taken place in close proximity to these yards.

Scrap yards fall into none of the classifications laid down in the Town and Country Planning (Use Classes) Order 1972, and it is up to the individual planning authority to decide if, for example, a small furnace, or other piece of equipment which is to be installed at an existing scrap yard, constitutes a material change of use and requires planning approval or whether it is merely ancillary to the existing business, and therefore no planning approval is necessary. This latter situation gives rise to many of our environmental problems.

One yard in particular in the West Midlands encapsulates many of the environmental problems which can be encountered. The land which this scrapyard now occupies was originally occupied by an ironfoundry, the operation of cupolas at which, had for many years caused serious fume, grit and noise problems to local residents. The foundry had occupied the site long before any planning legislation. In the early 1970s the ironfoundry closed and peace prevailed in the area for a short while until the foundry premises were bought by a large scrap metal company who wished to install two large sloping hearth furnaces for the recovery of aluminium. The land which the ironfoundry had occupied had an established use for melting metal and fell within Class VI of the Town and Country Planning (Use Classes) Order 1972, and the view was taken by the local Planning Authority that as metal melting was to continue on the site, the occupation of the site by the scrap metal dealer did not constitute a material change of use and therefore no planning approval was necessary.

The scrapyard is now firmly established on the site, and whenever the need arises works throughout the night. There are houses within 50 metres of the boundary of the site. Ferrous scrap, mainly in the form of vehicle engines, is cleaned by setting fire to piles of wooden pallets on top of which the engines are piled. Scrap containing aluminium is cut up with oxyacetylene torches causing fume and smoke. Aluminium is separated from the iron in sloping hearth furnaces which are poorly maintained and operated, giving rise to excessive dark smoke emissions, acid smutting and noise. Fork lift trucks, carrying metal to the furnaces and dross to a pile near the boundary of the site, create noise and dust problems. Burning of PVC from cable in order to recover copper takes place from time to time. Several prosecutions have been taken under Section 1 of both the Clean Air Act, 1956 and 1968 and a Nuisance Order is in force under Section 16 of the Clean Air Act 1956. Nevertheless, the fines are paid and the problems continue. Unfortunately there is insufficient public involvement to consider action under Section 100 of the Public Health Act 1936 or Section 222 of the Local Government Act 1972.

Because of the "established use" concept embodied in the current planning legislation, this scrapyard was able to occupy this land without reference to the local planning authority, thus perpetuating serious environmental problems which local residents had suffered for many years when the ironfoundry occupied the site. This loophole in the planning legislation was mentioned in the Fifth Report of the Royal Commission on Environmental Pollution,[8] and it is to be hoped that changes to prevent such occurrences will be made in the review of the Use Classes Order which is now taking place and that the whole question of "established use" will be looked at by the Working Party at present investigating the British planning system under the Chairmanship of Lord Flowers.

Two activities at scrapyards have manifested themselves over the past few years which are briefly mentioned above. These are the recovery of aluminium, particularly from scrap vehicle engines in sloping hearth furnaces, and the recovery of copper from insulated cable.

The sloping hearth furnace comprises a refractory lined box in which the floor slopes to a reservoir at the back into which molten aluminium flows. Oil burners are set in the sides of the furnace, and in some cases a small afterburning chamber is situated between the rear of the furnace and the chimney. The function of the furnace is to separate the aluminium from the iron, which is easily achieved as aluminium has a melting point of only 660°C against 1535°C for iron. From the reservoir the molten aluminium is ladled into moulds where it is allowed to set, or if the furnace operator is busy, sprayed with water to hasten solidification, producing copious amounts of steam. The majority of our prosecutions under Section 1 of the Clean Air Act 1956 relate to dark smoke emissions from these furnaces, which are usually designed to burn light oil, though it is common knowledge that, in many cases, waste engine oil is used but this is difficult to establish. This causes fouling of burners and smoke billows through partly opened and warped doors of the older furnaces when they are being charged or are overloaded.

Owing to the large amounts of PVC covered cable available, particularly the heavy armoured type, the burning of such cable to recover the copper is a common practice at scrapyards and by itinerants on open land. The practice is an offence under Section 78 of the Control of Pollution Act, 1974, unless the premises in which the burning takes place are registered with H.M. Industrial Air Pollution Inspectorate (the new title for H.M. Alkali Inspectorate). Under this Section (as amended by the Clean Air Enactments (Repeals and Modification) Regulations 1974), any officer appointed under Section 19 of the Health and Safety at Work Act, 1974, can take proceedings against offenders. This includes EHOs and H.M. Industrial Air Pollution Inspectors. This is the situation at the time of writing; however further amendments are due to be enacted, which will make EHOs responsible for cable burning in the open, whereas HMIAPIs will be responsible for cable burning in furnaces. During combustion of the PVC, chlorine is evolved mostly as hydrogen chloride, metallic chloride, or oxychloride fume. Originally phosgene was thought to be emitted during combustion but this now appears not to be the case. In the case of the heavy armoured cable a layer of lead is sometimes found under the outer PVC coating which further adds to the dangers when this material is being burned. Mechanical means are available for chopping up the cable and physically separating the PVC and copper but these machines are unsuitable in cases where loads of mixed cable are to be treated, and I have yet to see one in the West Midlands. HMIAPI requires as 'best practicable means' a furnace with wet scrubbing plant to reduce the hydrogen chloride content of the emissions to below 0.2 grains per cubic foot, and I know of only one large yard that has such a furnace.

I referred earlier to the weakness in the planning legislation which allowed the perpetuation of nuisance. In addition, close liaison between EHOs and planning officers is essential at all times where proposed developments are likely to give rise to, or be the victim of nuisance arising from existing premises. In my own Authority a good liaison exists and a senior EHO attends all meetings of the Land and Town Planning Committee. The lack of such liaison can be illustrated by a case involving a scrap yard in the West Midlands in the mid 1970s. The scrapyard occupied an extensive site bounded on two sides by industrial and commercial premises and fronted by a main road. At the rear of the site was an area of open land, which had previously been used for industrial purposes. The scrap yard had occupied the site from early this century and operated from early morning until late at night. In addition to the normal scrap handling processes, also installed at the yard were a swarf crushing machine and a metal briquetting machine which formed compressed steel briquettes using 400 tons of hydraulic pressure. When in use the briquetting machine emitted a high pitched whine, whilst the swarf crusher emitted low frequency vibrations and considerable intermittent banging from pieces of flying material striking the middle of the machine. These machines were housed inside a light building which was later partly built up with breeze block walling.

In 1973, without any consultation with the Environmental Health Department, planning permission was granted for 40 houses to be erected on the open land at the rear of the scrap yard, the nearest dwelling being only some 7 metres away from the building housing the crusher and briquetter. During the construction of the houses, the owner of the scrapyard erected a sign on his boundary fence facing the building site, stating: "Machinery operating from 6.00 a.m. to 11.00 p.m." This was countered by the house developers who obscured this sign by erecting a canvas screen. In addition, the owner of the scrapyard wrote to the Planning Department during the construction of the houses, and pointed out that a potential for noise nuisance existed, but by this time the development was going ahead.

Upon the houses becoming occupied, noise complaints inevitably arose. Noise readings showed that complaints were justified: corrected noise levels measured in accordance with British Standard 4142 ("Method of Rating

Industrial Noise affecting Mixed Residential and Industrial Areas") of between 73 and 75 dBA inside the nearest dwelling when the machinery was in use were recorded against a measured background level of 50 dBA, and a level of 96 dBA was recorded 10 metres away from the machines. A noise consultant's report also drew attention to vibration problems. An Abatement Notice was served on the owner of the scrapyard under the then Noise Abatement Act 1960, requiring him within 28 days to abate the noise nuisance by insulating the noise producing machines. The briquetting plant was removed from the building but noise nuisance continued. The noise consultant engaged by the Company concluded in his report that to attempt to reduce the noise and vibration to an acceptable level, by means of a heavy enclosure and an isolated inertia block, would not be economically viable and would involve a minimum outlay of £20,000 (at 1975 prices) and even after this work had been carried out, he could give no guarantee that no impairment to the working of the crusher would take place whilst being operated under such conditions.

The Abatement Notice was not complied with, and a Nuisance Order was made. The case eventually reached the County Court where the judge, in finding for the Local Authority, and commenting on the contents of a letter from the scrapyard owner to the Council, remarked that he (the scrapyard owner) might well be morally entitled to complain of the conduct of the Planning Committee. However, in law, although the occupants of the houses came to an existing nuisance, that was not a defence which was open to the apellant. The Company's appeal was therefore dismissed with costs. The remaining machine was eventually removed at considerable expense to another site. Consultation with the Environmental Health Department at an early stage would have undoubtedly drawn the Planning Committee's attention to the noise problems which existed, resulting, if not in a refusal of planning permission, at least in ensuring that dwellings were sited at such a distance from the scrapyard as not to be troubled by it.

Finally, I wish to refer to the question of contamination of land as a result of its occupation by scrap metal dealers. During the industrial recession of the past few years, several areas of land in the West Midlands, previously occupied by scrap metal dealers, have become available for redevelopment and careful consideration has to be given to whether the condition of the land is suitable for its proposed new use, particularly if this is to be for residential, school or agricultural purposes. Such a case has recently arisen in the West Midlands. A shallow disused sandstone quarry, which was occupied by several scrap metal dealers, was acquired by the Local Authority as part of a Compulsory Purchase Order with a view to residential redevelopment by the Council taking place. Soil samples were taken at regular intervals at a depth of .5 metre, over the 5 acre site. Analysis of these samples revealed excessive levels of lead, copper, chromium, cadmium, zinc, nickel and arsenic at one or more of the sampling points. As a result of these findings the Environmental Health Department recommended that the top layer of soil should be removed to a depth of one metre over the whole of the five acre site, and replaced by uncontaminated material. This exercise would involve the removal of some 25,000 cubic metres of material, some of it falling into the category of special waste, thus creating extra disposal problems. The cost of such treatment can be as high as £100,000 per acre.

Excellent guidance notes[9] are available on this subject of contaminated scrapyard and similar sites from the Central Directorate on Environmental Pollution at the Department of the Environment, and the Interdepartmental Committee dealing with this matter is interested to learn of "problem" sites and will provide whatever advice and assistance is possible within its terms of reference and available resources. In addition a draft British Standard Code of Practice for the identification and investigation of contaminated land has recently been published.

In conclusion, I have to say that the scrap dealers with whom I have to deal are a mixed bunch, generally shrewd, philosophical and not without humour, although on more than one occasion the presence of a police officer has been necessary to prevent violence (to the EHO that is!). Those whom we do prosecute usually plead guilty, pay their fines and carry on, regarding the EHO and the Clean Air Acts as an occupational hazard; and the three yearly renewal of the licence under the Scrap Metal Dealers Act 1964, which takes no environmental factors into consideration, is a mere formality.

As far as the Clean Air legislation is concerned, the time has surely arrived for a review of Section 1 of the Clean Air Act 1956 and its associated Dark Smoke (Permitted Periods) Regulations 1958, and the cumbersome procedure involved in the smoke nuisance provisions embodied in Section 16. Section 1 and the 1958 Regulations may have been appropriate in the days of hand firing of boilers 25 years ago but there can be no justifiable reason for the continual emission of smoke, under normal conditions, from modern boiler plant; the introduction of a best practicable means provision for all boiler plant and furnaces, of no visible emissions, would not, in my opinion, be unreasonable. Defences for lighting up from cold and unavoidable breakdowns etc. could be retained. This would also give us the opportunity of taking action in respect of emissions after dark and in weather conditions when smoke observations are not possible.

The Government's response[10] to the Fifth Report of the Royal Commission on Environmental Pollution promised a comprehensive review of air pollution legislation. I would suggest that this review start with Section 1 of the Clean Air Act 1956. It took six years for this response to appear; it is to be hoped that the review of the legislation will be given somewhat more urgency.

My thanks are due to Air Commodore Langston, Secretary General of the NSCA, for the opportunity to write this paper; to Mr. S.W. Hogg, Director of Environmental Health, Metropolitan Borough of Sandwell, for allowing me the use of departmental facilities; and to Mr. F.M. Shaw, British Cast Iron Research Association, and

Mr. T.H. Meredith, Director of Environmental Health Services, Dudley MBC, for their help and information.

The views and opinions expressed in this paper are my own and not necessarily those of my employing Authority.

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TORQUAY

OFFENSIVE TRADES

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1. OBJECTIVES

1.1 This paper is written with the following objectives:-

1. To identify the trades defined as "offensive" and the legislation which applies to them.
2. To show how the legislation provides less than adequate controls for society and the industry.
3. To suggest revisions of the present requirements which would improve controls and assist the community and industries affected to exist together without confrontation or nuisance.

2. INTRODUCTION

2.1 Offensive trades have been a part of society since man first decided to use or treat the inedible parts of animals he had slaughtered and eaten and convert them into useful materials. Their operations present unique difficulties, the control of which have caused severe problems to local authorities for many years.

2.2 Since the early 1970's in particular, detailed research has continued into the activities of these processors in an attempt to overcome the above problems. This effort has concentrated on quantifying odour emissions and the design, testing and installation of plant or equipment so it may operate without causing "nuisance". Much of the work was undertaken by the Warren Spring Laboratory of the Department of Trade and Industry. The Department of the Environment also established a Working Party in 1971 "to examine the problems of unpleasant odours emitted by offensive and selected other trades and to make recommendations about the best practicable means for their minimisation and supression". The Working Party comprised representatives of Government Departments, local authority associations, the Alkali and Clean Air Inspectorate and their Scottish counterparts, and experts from the Fish Meal and Animal Renderers Trades Associations. The Chairman was Dr. F.H.H. Valentin of Warren Spring Laboratory.

2.3 The results of the Working Party's investigations have been published and widely debated. With this in mind, other than drawing attention to their excellent reports and research data, I do not propose to discuss the technical aspects of any of the processes involved, but will concentrate on difficulties which arise through the existing system of control.

3. THE LEGAL POSITION

3.1 Historical

3.1.1 The first legal controls over "offensive trades" are found in the 11 and 12 Victorian statues of 1848 which provided that the businesses of blood boiler, bone boiler, fellmonger, slaughterer of cattle, horses or animals of any description, soap-boiler, tallow-melter, tripe-boiler, or other noxious or offensive business, trade or manufacture, were not to be newly established in any building or place without "consent". Infringements resulted in a maximum penalty of fifty pounds, with a further fine of forty shillings for each day the offence continued. Byelaws could be approved covering newly established businesses "in order to prevent or diminish the noxious or injurious effects thereof".

3.1.2 This was replaced by Section 112 of the 1875 Public Health Act, which essentially re-enacted the 1848 Act provisions apart from excluding the business of "slaughterer of cattle, horses or animals of any description" from the list of prescribed trades. The penalties were unaltered.

The trades of blood drier, leather dresser, tanner, fat melter or fat extractor, glue and size maker and gut scraper could be included within the controls as a result of the enactment of byelaws.

Section 114 of the 1875 Act made it the duty of an urban authority to institute summary proceedings against a defaulter, on receipt of a certificate from their medical officer of health, or from any 2 qualified medical practitioners, or from any 10 inhabitants of the district, stating that an offensive trades process or building was causing effluvia which was a nuisance or injurious to health.

3.1.3 In 1891 the London County Council were made the authority responsible for regulating offensive trades in the London area, making byelaws and taking legal proceedings. Certain businesses were prohibited from commencing after the Act was implemented. These were bone or blood boiler, manure manufacturer, soap boiler, tallow melter or knacker. Soap boilers could only operate provided that no animal oils or fats other than olein were used. Fellmongers, tripe boilers or horse slaughterers could begin trading only with the consent of the London County Council. The maximum fine for establishing a prohibited trade was £50 with a daily penalty of £50.

3.2 Contemporary

3.2.1 Public Health Act 1936 - Section 107 (as amended)

This section, dealing specifically with the control of offensive trades, states in subsection 1 - "Any person who on any premises within a borough or urban district, ... establishes, without the consent of the local authority, any offensive trade as hereinafter defined shall be liable to a fine not exceeding level three on the standard scale - at the time of writing £200 - see Criminal Justices Act 1982.

In this section "offensive trade" means -

(a) as regards the whole of the district of the authority, the trade or business of a blood boiler, blood drier, bone boiler, fat extractor, fat melter, fellmonger, glue maker, gut scraper, rag or bone dealer, size maker, soap boiler, tallow melter or tripe boiler; and

(b) as regards the whole or part of that district, any other trade, business or manufacture -

  (i) which immediately before 1st April 1974 was by virtue of any enactment an offensive trade in that district or part, as the case may be; or

  (ii) which the local authority by order confirmed by the Secretary of State and published in accordance with his directions have, on or after that date, declared to be an offensive trade in that district or part, as the case may be.

Provided that any order in force immediately before the date of commencement of this Act declaring the trade or business of fish frying to be offensive trade shall at the expiration of three years from that date cease to have effect for the purposes of this Part of this Act without prejudice, however, to the making and confirmation of a new order under this subsection".

Further subsections make provisions for a maximum daily penalty of £5 for continuing offences, and provide for appeals against refusals or time limits attached to consents and for the extension of the activities to be classified as offensive within a particular area.

Subsection 6 defines the phrase "established" as meaning - "For the purposes of this section, a trade business or manufacture shall be deemed to be established not only when it is established in the first instance, but also if and when -

(a) it is transferred or extended from the premises on which it is for the time being carried on to other premises; or

(b) it is resumed on any premises on which it was previously carried on, after it has been discontinued for more than eighteen months; or

(c) the buildings in which it is carried on are enlarged,

but a change in the ownership or occupation of the premises on which a trade, business or manufacture is carried on, or the rebuilding of the buildings in which it is carried on when they have been wholly or partially pulled down or burnt down, without any extension of the total floor space therein, shall not for these purposes be deemed to be an establishment of the trade, business or manufacture".

It will be seen that control is subject to "consent" by the local authority. The requirements are simple - the processor applies, the local authority considers and either gives or withholds its "consent". A time limit can be imposed but there are no provisions for granting a consent subject to conditions of any kind. Section 283 of the Public Health Act 1936 states that the "consent" must be in writing. In the light of the recent case of Epping Forest District Council v. Essex Rendering Limited, specific consent must be obtained and received by the trader in writing. Passive acceptance of the activity or even visits and advice on improvements or changes in operations or plant by officers of an authority do not amount to "consent". The specific requirements - few as they are - must be followed if legal proceedings are to be avoided.

Given the passage of time from 1848 to 1936 it is curious to observe the lack of changes in penalties which have taken place over the years. This is even more pronounced when one considers that the maximum penalty for establishing a trade without a consent was, until 11th April 1983, 135 years after the first legislation, a mere £50. As noted above it was increased to £200 by the Criminal Justices Act 1982. The daily penalty for continuing in business after consent has been refused or not renewed or "after receiving notice from the local authority to discontinue the trade" (Section 107(2) - again no detail of how or when to operate the procedure) has been increased from £2 in 1848 to £5 in 1936 and remains at the latter level today.

3.2.2 Byelaw Control (Section 108, Public Health Act 1936)

Local authorities are empowered to make byelaws "in order to prevent or diminish any noxious or injurious effects" of the trade, business or manufacture which is an offensive trade and which is carried on either in premises or in streets within their area. The Byelaws expire 10 years after they are made (or 3 years after the passing of the 1936 Act if made under previous legislation) unless the Minister, by order, extends the time limits. Model byelaws, Series XVI (1961) have been issued to guide local authorities.

3.2.3 Section 93, Public Health Act 1936

This section prescribes the procedure for dealing with "statutory nuisances" as defined in Section 92. The principal subsections likely to affect offensive trades premises are 92(1)(c) - "any accumulation or deposit which is prejudicial to health or a nuisance" - and 92(1)(d) (amended) - "any dust or effluvia caused by any trade, business, manufacture or process and injurious or likely to cause injury to the public health or a nuisance". Action under 92(1)(c) or (d) is subject to the statutory defence "that the best practicable means have been taken for preventing, or counteracting the effect of, the accumulation, dust or effluvia".

A more general definition is given in 92(1)(a) - "any premises in such a state as to be prejudicial to health or a nuisance" - but in every case the most specific part of the law should be used and this paragraph would be reserved for situations where poor housekeeping and inadequate cleaning were judged to be the cause of (odour) nuisance.

Action consists of serving an "abatement notice" on the person "by whose act, default or sufferance the nuisance arises or continues ..... requiring him to abate the nuisance and to execute such works and take such steps as may be necessary for that purpose". If abatement is not forthcoming, the local authority may seek a "nuisance order" from a magistrates court. As well as requiring the completion of specified works within a set time, in order to abate the nuisance and prevent its recurrence, the court may also impose a fine of up to £500 and award reasonable costs to the local authority. Should the nuisance order not be complied with, provision exists for returning the case to court, when a further fine and daily penalties may be applied for as long as the nuisance remains unabated.

3.2.4 Public Health (Recurring Nuisances) Act 1969

Where a nuisance has arisen and where an authority consider that it may recur on the same premises, they can serve a prohibition notice on the owner (in the case of structural matters) or on the person by whose act, default or sufferance the nuisance arose or, if that person cannot be found, on the owner or occupier of the premises, prohibiting a recurrence of the nuisance and requiring such steps as may be necessary to prevent a recurrence.

If the person on whom the notice is served fails to comply with it, or if a recurrence arises, a magistrates court may, on application by the authority, make a nuisance order following the procedure detailed for action under Sections 93 and 94 of the 1936 Act.

3.2.5 Section 99, Public Health Act 1936

This Section enables an aggrieved person to complain about an alleged statutory nuisance direct to a magistrates court. The resultant procedure is the same as for a local authority complaint except that an abatement notice is not served or required before the complaint is made. If the Court is satisfied that the only solution is to direct the local authority to abate the nuisance it must give them the opportunity of being heard before making the order.

3.2.6 Section 100, Public Health Act 1936

This Section enables an authority to take High Court proceedings to obtain abatement or prohibition of a statutory nuisance where they are satisfied that use of the magistrates court's procedures would afford an inadequate remedy. The defence of best practicable means is not available and there are no compensation requirements if the action succeeds. The Department of the Environment, having recognised that such action, if taken on a widespread basis, could effectively decimate the industry and leave local authorities responsible for the waste material, urged that these powers should only be used after careful deliberation. The section is entirely independent of the residual powers of a local authority to take proceedings under Section 222 of the Local Government Act 1972. This latter section enables a local authority to take, defend or appear in legal proceedings to promote or protect the interests of their inhabitants and to institute civil proceedings in their own name.

3.2.7 The Town and Country Planning Act 1971

As with any other land use proposal, planning permission will be required in the case of a new development, "change of use", and in the case of major extensions or alterations to existing plant. Planning legislation only provides future controls over land use when included as planning conditions imposed at the time planning permission was granted. Difficulties can be experienced in ensuring that planning conditions are reasonable, effective and enforceable and, bearing in mind that they cannot be amended following the granting of a permission, it is suggested that they offer only partial control and may present enforcement problems.

4. THE PRACTICAL POSITION IN 1983

4.1 Consider a hypothetical situation. An offensive trade has received planning permission and a "consent". It is operating. The local authority receive complaints.

The odour provokes a strong reaction from residents and local workers. What are the standards and what are the sanctions available? The Officer establishes a severe odour problem emanating from the offensive trade which is affecting the town centre and adjacent housing.

What controls/standards are available? The following options arise:-

(i) Planning permission - this aspect has already been settled.
(ii) "Consent" status - consent has been granted without time limit.
(iii) Is there a "statutory nuisance"? The professional opinion is that a statutory nuisance exists. If the company are unco-operative what can the authority do? Should a notice be served under Section 93 of the 1936 Act? Is the "best practicable means" defence applicable?
(iv) Would it be appropriate to seek an Injunction using either Section 100, Public Health Act 1936 or Section 222(1) of the Local Government Act 1972?

4.2 So far as option (iii) is concerned, if the conditions found at the premises are such that the housekeeping and cleaning could be faulted Section 92(1)(a) would seem to apply.

If stored raw materials were found to be the cause of the odour then Section 92(1)(c) would be appropriate. The authority must also consider whether the defendant can prove that the accumulation was essential for his business and had not been kept for longer than required. A defence that the "best practicable means" have been used to prevent the material from becoming prejudicial to health or a nuisance to local inhabitants may also apply. Case law seems to be lacking on this aspect.

Where process emissions or odours are implicated, Section 92(1)(d) - dust or effluvia - would seem to be available. Effluvia is not defined and again case law is of limited assistance. The "best practicable means" defence is available.

This paragraph was amended by the Local Government (Miscellaneous Provisions) Act 1982 to include nuisance caused to non-inhabitants of a neighbourhood. The author has experience of situations where offensive (trades) odours affected people who, prior to this Act, were outside the scope of the legislation. The amendment is therefore welcomed.

In Section 92 of the 1936 Act it is necessary to distinguish between the phrase "prejudicial to health" and "nuisance". Case law has determined that the situation needs only to be one or the other. The judiciary have defined "nuisance" as being "an act or omission which materially affects the material comfort and quality of life of a class of Her Majesty's subjects (- Watkins J. in the case of National Coal Board v. Thorne (1976)). Although the judgement related to Section 92(1)(a) which is premises-related, it seems appropriate to apply the interpretation to the whole of Section 92(1) as the attendant phraseology is identical except for the recently amended Section 92(1)(d).

"Prejudicial to health" is defined as meaning "injurious, or likely to cause injury, to health". As it is now generally accepted that odours do not cause disease this phrase is not normally used in proceedings against odour emitters. Arguments relating to physical danger, mental strain or depression, even if allegedly caused by continuous exposure to malodorous gases, are unlikely to be accepted by the Courts.

For practical purposes the issue reduces to "effluvia" being proved to be a "nuisance". This seems to be a complex process, without defined standards, relying in each case on the detail and perhaps ultimately the ability of the two parties to pay for lengthy and costly proceedings. The penalties can often be regarded as almost token in nature and effect and the time and resources utilised in repetitive prosecutions cannot be justified in any but exceptional circumstances.

4.3 Option (iv) refers to Section 222 of the Local Government Act 1972 and Section 100 of the Public Health Act 1936. It is apparent from these sections that a local authority can initiate High Court proceedings in their own name for an injunction to protect the inhabitants of their area or remedy a statutory (odour) nuisance. Following the judgements in Kent County Council v. Batchelor and Stafford Borough Council v. Elkenford Limited, they can proceed in this manner regardless of whether any other proceedings or statutory remedies have been used or exhausted, i.e. where they have evidence of a clear breach of statutory requirements. In the instance of an offensive trade established without consent, this action can be instigated without the need to take "nuisance" proceedings and "best practicable means" arguments do not arise. It can also be considered, threatened and if necessary used against a persistent odour emitter even where consent has been granted. It must be remembered that High Court action can be costly, especially where interim proceedings are taken, the results of which are reversed on full hearing of the facts, when substantial damages may be awarded against the local authority.

For the purposes of this paper let us assume the problem was resolved, eventually and with difficulty.

5. WHAT OF THE FUTURE?

5.1 In 1979 the Department of the Environment issued a consultation paper entitled, "Review of the Law of Statutory Nuisances and Offensive Trades". The Department's provisional conclusions appear below together with my comments:-

i. The concept of statutory nuisance should be retained (paragraph 2) - I agree.
ii. The duty of inspection imposed on local authorities by Section 91 should be retained (5) - retention essential.

iii. Certain detailed amendments should be made to Section 92(1)(d) (7) - some progress has been made but liquid "effluvia" and nuisances from non-trade or business premises remain unresolved.

iv. There should be an anticipatory power to deal with nuisances (9) - I strongly endorse this proposal.

v. The defence of best practicable means should be available in all summary proceedings relating to businesses and trades arising from Section 92(1) (12) - I do not agree. In any event "best practicable environmental option" has now been proposed as a replacement for BPM since the consultation paper was published. The possibility of BPM or BPEO being revised on a periodic consent or licensing basis allows progress in line with technological advances to be incorporated and would have a bearing on the usefulness of either concept.

vi. Provision might be made to deal with the effects of emissions on sensitive processes (15) - although I concede the principle, I foresee considerable difficulties in applying such a provision in practice.

vii. Consideration needs to be given to the revision of Section 100 (20 - 25) - I do not support the repeal of Section 100. A community needs to have available, through a local authority, the means to control or stop an activity, by due process of law, which poses a nuisance or health risk and Section 100 offers that last resort. As already stated above, I am not opposed to compensation provisions where planning permission has created unsatisfactory conditions.

viii. (Not relevant to this paper).

ix. An increase is needed in the number of trades defined as "offensive", as is a simpler procedure for adding to the list (34 - 35) - I endorse the conclusion of these paragraphs. There are many processes more "offensive" in character and more difficult to control. The existing definitions are 19th century in character and need extensive revision.

x. Existing consent powers should be continued (36) - I consider it important that powers to revoke consents and impose conditions should also be enacted and not just that the present powers should be retained.

xi. A continuing need for byelaws has still to be demonstrated (39) - I share the doubts expressed.

With the minor exception mentioned under paragraph iii, the present situation remains unchanged four years after the Department issued the consultation paper.

5.2 In general terms, the NSCA supported the revisions. The Society accepted the proposals regarding the extension of BPM to encompass "trade, business and manufacture" nuisances under Section 92(1); indeed one member suggested that its use should also be extended to private individuals. Support was also given for a redefinition of "offensive trades" but the Society did not wish to specify the precise trades.

The Institution of Environmental Health Officers also welcomed the revisions suggested. They suggested, however, redefining "effluvia" in Section 92(1)(d) to ensure that it included gaseous discharges and the escape of liquids, solids, gases or any compound, mixture or combination. They also sought an improved definition of BPM within the Act and its general use based on codes of practice. The concept of offensive trades should be retained with an enlarged consent procedure. They identified twelve trades which should be added to those already declared as "offensive" under the 1936 Act. These were:-

1. Any processing of pet foods.
2. Glass fibre manufacture.
3. Fumes from cellulose spraying.
4. Maggot breeding.
5. Manufacture of buttons from horns.
6. Storage and sale of bones on a wholesale basis.
7. Animal charcoal manufacture.
8. Tanneries.

9. Treatment and storage of animal and poultry waste, offal and remains.
10. Blood storage and disposal.
11. Fish and crab processing and waste processing.
12. Mink farms.

5.3 Apparently the Department of the Environment's proposed revisions and the responses thereon are still being considered. Four years have passed, the legal situation is unchanged, the anomalies and problems confronting local authorities and the trade remain, and, in my view, have worsened. Rationalisation of the industry has allowed for economies of scale in capital investment. Larger plant and sites can justify expensive pollution control technology but if emissions arise they too can be of greater significance and can create new hazards. As changes in processes are introduced and transport costs escalate, the storage of chemicals associated with the large rendering operations may also increase with a greater potential for hazardous products such as benzine being stored on site. Although other controls exist through Health and Safety legislation it may be appropriate to consider maximum storage capabilities when assessing consent requirements.

I am also concerned that the present list covers only the specific trades mentioned and not the transport, storage and handling stages of the industry. By-product transfer stations and sorting operations can create as serious a nuisance as processing operations. Although some larger companies convey materials in totally enclosed containers, a transient odour is still noticeable in towns and cities on the routes leading to some processing sites.

I am also concerned at possible contamination of the sewerage system and water courses. Despite the best efforts of the appropriate bodies serious accidents can occur. Special precautions, including in-house treatment, are recommended which must be operated to the highest standards. All practical precautions should be taken to ensure that the possible spread of infectious or noxious material by birds, rodents or other animals cannot take place as the potential effects of this could be disastrous to all concerned.

I strongly endorse the views of the Society and IEH regarding changes needed to the present legislation. The list of trades must be widened to embrace those suggested earlier and all manufacture, processing, handling, storage and transport of products relating to those industries. Penalties must be realistic and offenders should be liable to disqualification. I endorse the need and use of daily penalties but again these must be realistic.

5.4 The future may not be entirely without hope. The EEC have recently published a Proposal for a Council Directive on the Combatting of Air Pollution from Industrial Plants. Although primarily aimed at major polluting industries, it contains provisions relating to nuisances, a prior authorisation procedure, and control through a "state of the art system". Of significance in the context of this paper are proposals to include food industries, waste disposal and industrial livestock rearing installations. The Food Industries Group includes abattoirs, fish meal and fish oil factories processing 100 tonnes or more per day, and the production of oil or fat from plant or animal sources. Waste disposal includes plant for the disposal of solids or liquids by combustion or chemical decomposition and plants for the disposal of animal carcases.

I can only speculate as to the outcome of these proposals and suggest that the delay on the part of the DoE so far as the revisions to the Public Health Act are concerned may be caused by a wish to ensure compatability with legislation required to bring the proposals into effect.

6. CONCLUSIONS

By way of recommendations for further action, I suggest the following:-

(i) The introduction of a revised consent procedure enabling conditions to be included on storage, handling, processing and transport of offensive materials and provisions for the adoption of Approved Codes of Practice.

(ii) A new definition and list of offensive trades incorporating the additions suggested above.

(iii) A complete revision of the "nuisance" control procedure.

(iv) A complete revision of penalties and the introduction of disqualification procedures.

(v) The production of a series of Codes of Practice to define operating standards.

I consider that the adoption of the above recommendations will clear the way for a system of control which will be more suited to the needs of the approaching 21st century rather than those of the Industrial Revolution. It remains to be seen whether the Government will accept the challenge.

7. ACKNOWLEDGEMENTS

Whilst the author gratefully acknowledges the assistance of his colleagues in the Bristol City Council Environmental Health Department and elsewhere, the views expressed do not necessarily reflect the policies or opinions of the City Council.

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TORQUAY

INDUSTRIAL MAJOR HAZARDS AND THE PROTECTION OF THE COMMUNITY

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INTRODUCTION

1. An Industrial Major Hazard is, like an elephant, difficult to define exactly but easy to recognise. This paper is concerned with the large, infrequent accidents at factories or other industrial installations which can cause much damage and casualties on and off the site. The explosion at Flixborough in 1974 is the best known example in the United Kingdom. The primary concern of the Health and Safety Executive is the health and safety of people, whether they be workers on the installation or residents nearby. The necessary care to ensure the health and safety of people almost always means that the environment is also protected and, in fact, the relevant European Council Directive on the major accident hazards of certain industrial activities requires specific attention to be paid to the environment.

2. Thus a major accident hazard is one which is liable to produce widespread damage outside the confines of the workplace and may kill several people by means of fire, explosion or release of toxic material. Such accidents are by nature sudden, acute events and are very different from low level, continuous releases of material such as the pollution of water courses by effluent or the emission of toxic gases from factory chimneys. They may have an effect not only on farm animals and cash crops but also on water courses, wild animals, and the natural vegetation.

History

3. The development of new technologies and the creation of new industries brings new problems for Government, and this has been the case throughout the history of the industrialisation of the United Kingdom. At first general industrial safety requirements were covered by piecemeal legislation, but later such requirements were brought together in the Factories Acts. The Factory and Workshop Act (1878) was the first attempt at comprehensive factory legislation. Matters covered by this and subsequent Acts include fire precautions, conditions of

employment, and hygiene, in addition to regulations covering particular dangerous trades.

4. Additional Acts were passed to control particular dangerous technologies or industries as the need arose. Thus the Boiler Explosions Acts of 1882 and 1890 were designed to improve the safety of steam boilers. By requiring that all steam boilers be built to adequate standards and be fitted with various safety devices such as safety valves and fusible plugs, the incidence of boiler explosions was reduced to a very low level.

5. Similarly, the Explosives Act (1875) was introduced to control an industry which had developed an unsatisfactory safety record. Explosives manufacture and storage is regulated by a system of rigorous controls including licensing and inspection. In addition, the manufacture of certain materials is specifically forbidden.

6. Early this century the Alkali etc Works Regulation Act (1906) laid the foundations for the control of air pollution and the protection of the environment and has lasted through to the present day.

7. Nowadays industries are mainly regulated by the Health and Safety at Work (HSW) Act of 1974 which has swept up all the preceding, separate pieces of legislation into one powerful Act. The regulations which are being introduced to control major hazards are made using the powers in this Act.

Examples of Major Accidents

8. The development of safety legislation in the UK in the last ten years has been greatly influenced by two different but particularly serious industrial accidents; one was the explosion at Flixborough in 1974, the other was at Seveso, Italy in 1976.

9. The Flixborough disaster involved the works of Nypro (UK) Ltd and was caused by the accidental release of an

estimated 40 tonnes of highly inflammable cyclohexane vapour. The release was probably due to the failure of a pipe, half a metre in diameter, which had been inserted to by-pass a defective reactor in a chain of reactors which were carrying out a process involving the heating of cyclohexane under pressure. The vapour release, which occurred in less than a minute, was followed by a violent explosion, which devastated the works and killed 28 people (all inside the factory). A further 89 people were injured, 53 of them outside the factory.

10. The incident at Seveso also involved the accidental release of material from a pressurised reactor, but otherwise the situation was very different from that at Flixborough. It appears that the reactor involved had been shut down for the weekend and left unattended when the incident took place. Failure occurred due to a runaway reaction which produced much heat and highly toxic TCDD (2, 3, 7, 8 tetrachloro - dibenzo - p - dioxin) as an accidental by-product. TCDD is a persistent material and although only a few kilogrammes were dispersed over a wide area,.an expensive clean-up operation was necessary to make contaminated land habitable or suitable for agriculture. No human lives were lost but some farm animals died and others had to be destroyed.

11. The disasters at Flixborough and Seveso well illustrate the diverse hazards presented by industry today. The Flixborough disaster killed or injured over a hundred people but had no long term environmental effects; whereas the Seveso incident caused serious long term environmental damage but killed no one directly.

THE UK APPROACH TO REGULATION

The Health and Safety at Work, etc. Act (1974)

12. The United Kingdom is well advanced in the development of general health and safety legislation, which is increasingly based on the Health and Safety at Work etc

(HSW) Act (1974). The HSW Act covers nearly all people at work and is aimed at people and their work activities rather than premises and processes as was the case in previous Factories Acts. The legislation includes provisions to protect people at work and to reduce the risks to the health and safety of the general public which may arise from work activities. Previously most safety legislation had been concerned only with protecting the worker. So the provisions to protect people outside the boundary fence from possible accidents inside it represent a major change and one which makes possible many of the developing controls for major hazards.

13. The HSW Act does not contain specific references to protection of the environment but it does allow relevant information to be passed on to authorised persons for purposes which include the protection of the environment. The Alkali etc Works Regulation Act, mentioned above, which is a relevant statutory provision of the HSW Act, is used to control emissions for the protection of both man and the environment. Moreover the HSE has always believed that measures which protect man will usually also protect the environment.

14. The HSW Act also established the Health and Safety Commission (HSC) to preside over safety matters with the Health and Safety Executive (HSE) as its executive arm.

The Advisory Committee on Major Hazards (ACMH)

15. The Flixborough disaster of 1974 caused the hazards arising from industrial activities to receive renewed attention from both Industry and Government. It was recognised that since 1945 there had been a considerable increase in the scale and diversity of industrial activities using dangerous substances, both old and new, with a corresponding increase in the severity of the likely consequences of an accident. Therefore an immediate result of the Flixborough disaster was that the HSC appointed the Advisory Committee on Major Hazards to advise on the problems.

16. The ACMH consists of a group of academics, consultants and other independent experts drawn from a wide variety of disciplines and representing employer, trade union and local authority interests as well. It was asked to identify industrial installations (excluding nuclear installations) presenting a serious threat (major hazard) to employees or to the public or to the environment. The Committee was also asked to recommend ways of controlling such installations.

17. To date ACMH has published two reports, one in 1976 and the other in 1979, and has considered installations presenting a major hazard as a result of explosion, fire or the sudden release of a toxic substance. The Committee has made three main recommendations:-

(i) Firms that use more than a specified quantity of a dangerous substance should notify the HSE of their location and the activities in which they are involved.

(ii) There should be improved planning controls for such notified sites and also for developments in the vicinity.

(iii) Firms handling very large quantities of a dangerous substance should be required to carry out a hazard survey of their site and report to the HSE.

Action has now been taken or is in hand on all three of the ACMH proposals and is described in following sections of this paper.

THE NOTIFICATION OF INSTALLATIONS HANDLING HAZARDOUS SUBSTANCES (NIHHS) REGULATIONS (1982)

18. The Notification of Installations Handling Hazardous Substances (NIHHS) Regulations (1982) came into force on 1 January 1983 under powers conferred by the HSW Act (1974), and implement the first of the ACMH proposals.

19. The scope of the NIHHS Regulations is very wide and in general the Regulations require that any installation

in Great Britain where there is present more than a specified quantity of certain hazardous substances should be notified to the HSE. The term 'installation' is all-embracing and refers to any industrial site including factories, warehouses, transit depots and pipelines. The hazardous substances are listed in a schedule to the Regulations together with the relevant notifiable quantities, and in all there are 35 named substances or classes of substances. Some attempt was made to ensure that the specified quantities represented equivalent hazards. This is reasonably possible for explosion hazards, where the levels correspond to a few tons of TNT, but it is very difficult to set an equivalent standard for toxic substances. So liquefield petroleum gas (LPG) is listed at 25te, some ammonium nitrate fertilisers at 500te, sodium chlorate at 25te and chlorine at 10te.

20. The Regulations do not apply to transportation of hazardous substances to or from sites but may apply to stationary ships or vehicles used for storage purposes.

21. Information contained in the notifications is limited in the interests of simplicity but covers the following points (among others):

(i) Name and address of the persons making the notification.

(ii) The address of the site where the notifiable activity will be carried out and the date of commencement.

(iii) A general description of the activities carried out and the maximum quantity of each hazardous substance for which a notification is being made.

(iv) The name and address of the planning authority in whose area the notifiable activity is being carried out.

The notifications should therefore give the HSE a coherent picture of the industrial activities being carried out in the UK which involve large quantities of hazardous substances. Such information will be used for defining inspection priorities. In addition, the preparation of the notifications should remind employers and employees of the hazards arising from their activities.

22. The HSE has made arrangements to pass on to the local planning authorities the information contained in the notifications to help them in development control matters. Circulars from the Department of the Environment and the Scottish and Welsh Offices advise planning authorities to consult the HSE about major hazard installations and developments nearby. Sometimes more than one part of the HSE will have an interest in a particular development; for example, a notifiable LPG tank on a brick works would interest both the Industrial Air Pollution Inspectorate and the Major Hazards Assessment Unit. We have therefore made internal arrangements for co-ordination which mean that the local planning authority need only make one approach to the HSE, through the local area office of the Factory Inspectorate.

23. Information contained in the notifications and any necessary advice is also made available to Fire Brigades so that they are aware of the special hazards involved.

24. In addition to the recommendation concerning notification, ACMH also suggested that firms handling very large quantities of a hazardous substance should carry out a hazard survey and submit a report to the HSE. In fact, the HSC originally intended to implement the ACMH recommendations for notification and hazard surveys in one set of regulations, and a Consultative Document was issued in 1978. However this plan was overtaken by events, and the proposal for hazard surveys will now be implemented with the EC Directive on the Major Accident Hazards of Certain Industrial Activities (Seveso Directive).

PLANNING CONTROLS

25. The ACMH declared that the safe location of a major hazard plant is essentially a matter of town and country planning and should not be divorced from other planning considerations. Planning controls are the responsibility of the Department of the Environment (DoE) in England and of the Scottish and Welsh Offices in other parts of Great Britain. Northern Ireland makes its own arrangements, but they are very similar. The legislative support for these controls is provided by the Town and Country Planning (TCP) Act (1971) and the associated General Development Order (GDO) and Use Classes Order (UCO).

26. The ACMH went on to recommend that planning controls for notified sites and developments in their vicinity should be strengthened, as some major hazards are introduced without any specific planning permission. This is because the TCP Act defines development in a way which gives some freedom for changes in the use of land and premises without the need for express permission. This latitude is extended by the UCO (1972) and in addition permitted development rights under the GDO may also allow the creation or intensification of hazardous developments.

27. The HSC accepted the recommendations of the ACMH and accordingly approached the Secretaries of State for the Environment, Scotland and Wales with suggestions for planning changes. The DoE and Scottish and Welsh Offices agreed that there are loopholes in the existing planning legislation and they intend to close as many of them as possible. They issued consultation documents on the subject at the end of last year. At present they will probably only amend the GDO and UCO, but the possibility of changing the TCP Act at some future date has not been ruled out. The GDO will probably be amended to exclude quantities of hazardous substances listed in the NIHHS Regulations. In addition, developments which increase the quantity of a notifiable substance held at a site, by a factor of three or more, may also require planning permission.

28. Unfortunately these probable changes may still not catch all new notifiable major hazards. The amended GDO and UCO would probably not catch, for example, a warehouse used for storing milk powder which then took in a notifiable quantity of sodium chlorate, because this might not constitute a material change of use, within the meaning of the Act.

29. At present local planning authorities consult HSE voluntarily about planning applications involving notifiable installations and developments in their vicinity, as recommended in DoE Circular 26/82 etc. However, a probable amendment to the GDO will make consultation with HSE mandatory for planning applications involving the notifiable installations themselves. Consultation on developments in the vicinity of notifiable installations will remain on a voluntary basis.

30. The major role played by the HSE in risk assessment and advising on safety aspects of planning matters, even under existing arrangements, is best illustrated by the three planning inquiries at Canvey Island. In all three the HSE provided key witnesses from HM Factory Inspectors in the area and from the Major Hazards Assessment Unit at Headquarters. The report of the final inquiry by Mr Alan de Piro Q.C. stated that the HSE's evidence 'was independent, unbiased and reliable' and carried great weight with him. The findings of this report have been accepted by the Government.

THE EC DIRECTIVE ON MAJOR ACCIDENT HAZARDS

31. The EC Directive on Major Accident Hazards of Certain Industrial Activities (EC Directive) was drawn up by the EEC to improve control of industrial hazards following incidents such as those at Flixborough and, especially, at Seveso, Italy in 1976. The EC Directive, which incorporates proposals very similar to the recommendations of the ACMH for hazard surveys, was agreed by member states in June 1982. It is due to be implemented by 8 January 1984.

32. The main objectives of the EC Directive are the prevention of major accidents arising from industrial activities and the limitations of the effects of such accidents both on man and on the environment. The industrial activities covered by the Directive are defined in such a way as to embrace most of the chemical and petrochemical industries using substances with dangerous flammable, explosive or toxic properties.

33. Although the Directive lists more dangerous substances than the NIHHS Regulations, its scope is less all-embracing in other ways because it defines relevant activities in a restrictive way. Thus, for example, the Directive largely misses LPG used as a fuel, say at a brickworks. Moreover some industrial activities are specifically excluded from its provisions. Thus the Directive does not apply to nuclear, military and waste disposal installations, all mining and quarrying operations and the manufacture and separate storage of explosives and munitions. In addition, the Directive distinguishes the process use of a dangerous substance from isolated storage, in a warehouse say, and applies very relaxed controls to the latter.

34. The requirements of the Directive can be considered as being at two levels. In an attempt to underpin the whole field of handling dangerous chemicals there are some general provisions aimed at avoiding major accident hazards wherever they might occur in chemical industries. Additionally, some of the largest or potentially very hazardous installations are identified and attract further, more stringent controls. Apart from consideration of effects on the environment, the low level or general requirements approximate to those of the UK HSW Act.

35. The specific requirements apply to appropriate installations with inventories above prescribed thresholds. For process activities there are 178 listed substances or classes of substances. For isolated storage there is a limited list of only 9 substances, with greatly relaxed thresholds. The dangerous

substances can be classed as toxic, flammable, highly reactive and explosive substances. Examples are as follows:-

Nickel (powders, compounds)	100kg
Chlorine	50te
Ethylene oxide	50te
Ammonium nitrate	5,000te
2, 4, 6 trinitrotoluene	50te
LPG	200te
Petrol	50,000te

36. Thus manufacturers in charge of such installations in the UK will be required to provide HSE with detailed information on the safety aspects of their activities. This amounts in effect to a safety report and must include a hazard survey of the installation with other information as below:-

(a) Details of substances used at the installation and associated hazards.

(b) Details of the installation, including maps and plans of the site and a description of any processes being carried out.

(c) Details of the management of the installation and information on people working on the site.

(d) Details of potential major accident situations and of measures and arrangements that are available to prevent or limit such accidents. This will include emergency plans for use inside the establishment and information to be made available to members of the public likely to be affected by a major accident.

37. The HSE will be responsible for examining safety reports to make sure they are satisfactory in scope, depth and in their conclusions. Essentially, the HSE will ensure that the system of control is adequate for potential major accident hazards.

38. Local authorities will be responsible for preparing emergency plans for use outside establishments and

manufacturers will be required to provide information as necessary.

EMERGENCY ARRANGEMENTS

39. As mentioned briefly above, the EC Directive will make the provision of emergency plans for upper level installations mandatory, as part of the system of control for such installations.

On-Site Plans

40. On-site emergency plans will be the responsibility of site operators and must be of sufficient scope and quality to deal with a major accident.

The following points will need to be covered:-

(a) There must be a written plan including the names of people responsible for safety on site and authorised to take action in an emergency.

(b) There must be essential equipment - warning devices, fire fighting appliances, water supplies, protective clothing, etc. - available.

(c) There must be prepared arrangements for invoking the help of the fire, police and ambulance services.

(d) Training and exercises must be carried out.

(e) The plan must be kept up to date.

41. The HSE will effectively be responsible for approving on-site emergency plans as they will be part of the safety report.

Off-Site Plans

42. Local or county authorities will be responsible for drawing up and maintaining off-site emergency plans for the larger prescribed installations. This will be done on the basis of information supplied by site operators and in consultation with the HSE, emergency services and

other bodies as necessary. Some councils already have such plans and the importance of consultation between the interested parties has been well demonstrated.

43. Existing emergency plans will not necessarily be affected by the statutory requirements, but local authorities will have to make sure that all designated installations are covered by their arrangements.

44. Emergency plans must be dovetailed with the on-site plans and maintained in a state of readiness; provision will have to be made for training and exercises. In addition to helping the operator deal with the immediate effects within the boundary fence, the emergency services will have to be prepared to cope with possible consequential effects in the surrounding areas. Off-site effects would usually take longer to develop and allow some time to put precautions into effect. Equally they may continue for a period of several hours, or even days, and require considerable mobilisation of resources to cope with possible evacuation, restriction of access, banning of the movement of foodstuffs or the use of water supplies and subsequent decontamination.

45. The HSE will have an important advisory role to play and will be able to provide guidance on hazards and risks involved, based on information received in safety reports.

INFORMATION TO THE PUBLIC

46. There is growing public awareness of the potential hazards presented by both old industries and new technologies using dangerous substances in ever larger quantities. Some parts of our society are more worried than others. Probably most people living close to a factory are vaguely aware that there might be some danger to them from a severe accident at the factory, especially with chemical factories. In this field, as in many others, the question arises as to how much people should be told. There is little disagreement that people who may have duties to perform in an

emergency should be told as much as they need to know. This covers the fire, police and ambulance services together with anyone else involved in the emergency arrangements.

47. There are also the people who are likely to be affected by an accident; how much should they be told? The Directive makes it mandatory for people who may be affected by an accident at the larger prescribed installations to be told of the safety measures and the correct behaviour to adopt. Such information must be given before the event; its extent will depend on circumstances but should cover the following points:-

(a) A statement that the industrial activity is subject to the provisions of the EC Directive and has been notified to HSE.

(b) The nature of the major accident hazards, e.g. fire, explosion or release of toxic material.

(c) The safety measures and the correct behaviour to adopt in the event of a major accident.

48. There are difficulties in providing information about these installations to the public because of the importance of commercial secrecy, security matters and the need to avoid causing undue alarm. The duty to provide such information must rest with the operator; he could also be required to pass it on to the public involved. However there is a strong body of opinion which believes a better course is to place a duty on the local authority to receive appropriate information from the operator and then to carry out the dissemination of it. It is argued that this would avoid confusion and ensure that the advice was consistent with the arrangements in the off-site plan. It is also argued that the public expects to receive this sort of information from the local authority whom it trusts, rather than from the operator whose vested interest is well known. That the preferred route is via the local authority is fairly clear, but whether this can be done by arrangement or needs to be prescribed as a duty on

local authorities has not yet been decided. Who will bear the costs is also under discussion.

CONCLUSIONS

49. The need to control hazardous industrial installations has been recognised and some powerful controls are being put in place. The fact that the dangers have been recognised and controlled before too many major accidents have taken place reflects some credit on our society. It is certain that we all appreciate the benefits that these factories confer on our way of life. It is likely that we can reduce the risks to acceptable levels. Local authorities, both the elected members of the local communities and officials, have a special part to play in ensuring that a fair balance is struck and maintained between risks and benefits.

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LOCAL AUTHORITY INCIDENT RESPONSE – THEORY AND PRACTICE

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SUMMARY

This paper describes, in general terms, the way in which a local authority should prepare itself to deal with environmental incidents which may affect the community. Particular reference is made to the way in which the environmental health department should respond. Difficulties associated with a typical incident are illustrated by a case study of a major fire which occurred in a warehouse storing a mixture of inflammable chemicals and herbicides. The need for the consolidation of experience is considered.

PART I THEORY

INTRODUCTION

It has been made clear that the responsibility for the identification of 'major hazard' installations rests with the Health & Safety Executive. Their inspectorate make regular visits to premises where chemicals are manufactured, processed and refined, where hazardous substances are stored and where other operations, which may have a hazard potential, are carried out.

The HSE Major Hazard Unit will advise, at the planning stage, on the suitability of establishing a potentially hazardous activity on a particular site. They will also assist the planning authority in considering the implications of permitting residential or other, sensitive development in the vicinity of existing 'hazardous' operations.

This paper explores the role of the local authority in anticipating and responding to emergencies. It has not been possible to lay down detailed ground rules of an incident response system in this paper because of differences of size and function between individual local authorities. Suggestions are, however, given on those aspects of response which have environmental health implications. An example, based on an actual incident, is then discussed because it is only through experience that procedures can be fully developed.

INCIDENT RESPONSE PROCEDURES

Emergency planning is carried out by both district and county councils. There is no one authority or department which can respond to all types of incident and no one officer who will have sufficient technical skills or legal authority to be able to cope with all types of problems. To be effective a procedure must rely on co-ordination, co-operation and communication.

Overall co-ordination is best carried out by an officer who has a broad understanding of all of the duties of statutory bodies and other agencies, including voluntary bodies. This role can be filled by any experienced person and is often undertaken by an individual with a background in administration. With the exception of the county council it is unlikely that the duties would be so onerous as to require the creation of a full-time post.

Having identified a co-ordinator (and adequate support) a general procedure can be drawn up which will enable a proper response to be given to any incident. It should, however, be remembered that incidents will occur in accordance with Murphy's Law - that is, "If anything can go wrong it will". From this it will be found that incidents are most likely to occur outside normal working hours and generally to have been caused by a combination of circumstances that could not have been foreseen.

It is normally the police and the fire authority who are first called to an incident, and it is therefore vital that they are fully aware of the support which can be given by the local authority. In order for this to be possible a written statement of locally available resources must be produced and made available. This should identify people to be contacted and summarise the help which each department can give. It is important that the maximum number of contacts is identified in such a document. Few local authorities can afford, or justify, having representatives from all support departments on formal stand-by at every hour of every day of the year so an adequate list of alternative officers should be identified. (Procedures should be revised regularly - at least annually - to take account of staff movement).

The establishment of an incident procedure is likely to require involvement of both members and officers of a number of local authority departments. Some local authorities have established ad hoc committees to co-ordinate such inter-departmental activities and to monitor the way in which a response is made to particular incidents. This body could attempt to draft detailed response procedures for a wide range of defined incidents but, unless a particular problem has been identified, the allocation of considerable time to hypothetical studies may not be justified. Where there is a likelihood of a specific incident, for example flooding, the drafting of a specific contingency plan is, of course, necessary.

One situation which requires special anticipatory planning concerns the emergency procedures related to nuclear power stations. The Health and Safety Executive have already produced general guidance on this subject, which draws attention to the existence of emergency plans for nuclear plant. Although the guidelines do not make specific reference to the environmental health department, that body may have a role to play. Any local authority with a nuclear plant in their area must ensure that they liaise with the appropriate bodies.

Other major organisations draw up their own emergency plans which lay down the action to be taken 'on-site' in the event of plant failure or a similar disaster. Obviously there is a limit to human foresight and certain types of incident may never be anticipated. It is also possible that the likelihood of catastrophic failure, on the scale of Flixborough or Seveso, may never be admitted, even if recognised, because of the adverse public reaction which such a disclosure would generate. Despite these misgivings local authorities should seek to involve themselves with local major industries in order that consideration be given to possible 'off-site' implications of accidents which have been foreseen.

DEPARTMENTAL ROLES

It is not within the scope of this paper to suggest how housing or social service departments should participate in emergency planning. There is even some difficulty in suggesting exactly what is required from the environmental health department. Some see the environmental health officer attending an incident, say a fire at a chemical works, with a complete set of gas detection tubes and sufficient technical information to be able to advise on evacuation procedures. Others envisage a more passive role.

Unless the nature of all emissions from a site can be identified long in advance of an incident and unless there is no likelihood of any other emission being produced, then the use of gas detection equipment would not enable reasonable assessment of risk to be made. In the event of a fire or similar uncontrolled event it is unlikely that anyone will have a clear understanding of exactly what is being emitted. In such cases evacuation decisions may be more reliably based on the philosophy, "If possible toxic smoke is drifting towards dwellings then evacuate". The alternative of monitoring may waste valuable time and can never allow measurement of all possible toxic gases. Such measurements would not, for example, identify asbestos fibres.

EQUIPMENT

Those responding to an incident will require access to certain equipment and other resources. It is assumed that the environmental health officer will have normal protective clothing in his car but individuals involved in call-out procedures should also have the following available for immediate use:-

Torch (batteries separate - renewed every six months, regardless of use)
Notebook
Pens and pencils
Waterproofs
Copy of incident procedure
Change for telephone

Provision of more specialist equipment seems unnecessary as it is unlikely that the environmental health officer would find himself at the 'front-line' in an emergency.

Although some local authorities appear to have access to two-way radio systems for use in incidents, they seem to be the exception rather than the rule. (In any case some large authorities have radio black spots where transmission is not possible.) Generally one has to rely on public telephones as the police are not always able to relay messages. It is useful to have several pounds in suitable change to enable effective communication.

It is equally important for the responding officer to have all of the telephone numbers which may be needed. Telephone directories are not always available in such circumstances. Included should be the numbers of local councillors so that ward members and committee chairmen can be acquainted with the situation.

One approach which simplifies communication is for a minimum of two officers to be called to each incident; one to operate at the scene of the problem and the other to man a control room. In theory this is advantageous but manning arrangements must be more formal to ensure coverage. (Remember that Murphy's Law indicates that if anything goes wrong it is more likely to do so on Good Friday or the evening of the Department's Annual Dinner/ Dance!)

The need to have sundry goods packed seems questionable but when the telephone rings in the middle of the night it is sufficiently difficult to cope with the simple task of dressing without adding unnecessary complications.

Some form of refreshment, such as non-perishable confectionery, is also worth inclusion. Officials involved in attending incidents should also have some form of identity for their vehicle to assist in gaining access to the vicinity of the problem. A card which can be fixed to the passenger's sun visor should suffice but consideration should be given to this at a preliminary stage in the establishment of the incident procedure.

Two additional pieces of equipment which are useful are a pocket dictating machine and a camera. The former is most useful to keep a running log of events when working under pressure. It is, however, important to ensure that fresh batteries are available together with a waterproof bag to enable operation in rain. The camera enables a permanent record to be made of scenes from the event.

If there is a major incident it is likely that the media will find their way to the scene. Officers who are expected to attend incidents should be authorised to talk to the press in order that recognition can be given to the response made by the authority. This may require senior management to consider the nature of the comments which can be made, especially if there is the prospect of any agency taking legal action in relation to some aspect of the incident.

RESPONSE AND AFTERMATH

Having identified those officers who can be available to respond to incidents and equipped them with the necessary hardware, much has to be left to the discretion of the individual once a problem occurs. Opportunities for providing training in this sphere of work seem few. It is therefore important to carry out a critical examination of each response in order to determine if there is any need for modification to the system. It is only by rigorous self scrutiny that the efficiency of such operations can be developed.

PART 2 - PRACTICE

INCIDENT AT WOODKIRK, NEAR LEEDS

INTRODUCTION

This is a report of an actual incident which recently occurred in Leeds. On the morning of Saturday 13th February 1982, packers were at work preparing pallet loads of goods for despatch in a warehouse on the premises of Messrs. Universal Freight Organisation (Holding) Limited, Quarry Lane, Woodkirk. At about 10.00 a.m. they left the warehouse for a tea-break. At approximately 10.15 a.m. local residents heard a muffled explosion and smoke was observed issuing from the warehouse.

The fire and the subsequent fire fighting were to result in the release of huge quantities of diquat and paraquat into the environment. The effect on the residents, their gardens, the local watercourse and the surrounding area was devastating. Even now, over twenty months after the incident, dead trees, ruined lawns and continuing minor pollution of the local stream bear mute testimony to the scale of the disaster.

THE COMPANY AND THE SITE

The Company operates a freight distribution depot on the site of a former brickworks which straddles the boundary between the Metropolitan Districts of Leeds and Kirklees to the south of Leeds (see appendix).

Quarry Lane runs in a westerly direction from the main Leeds to Dewsbury trunk road (A653) and serves a large brickworks, two former quarries which are now waste disposal sites and a plant hire firm in addition to the company concerned. The lane and the surrounding land slopes gently in an easterly direction. The boundary between the local authorities is formed by a small stream, now culverted, bisecting the UFO site then running to the rear of properties in Quarry Lane and roughly parallel to the lane. The culvert passes under the A653 to continue as an open watercourse across fields, eventually discharging into the River Calder which itself merges with the River Aire at Castleford and eventually flows into the Ouse/Humber system.

At the time of the fire the company were operating as a holding depot for ICI Herbicides. The warehouse concerned contained approximately 325,000 gallons of diquat in 200 litre drums and approximately 10,000 gallons of paraquat in 5 litre polythene containers. It also contained some 20,000 Kg of octyl-phenol.

THE INCIDENT

The Fire Services have since said that it was not possible to state with any degree of accuracy the exact cause of the fire although two possibilities exist. Firstly, the pallet loads, which included octyl-phenols, were being enclosed in polythene sheeting which was then shrunk onto the loads by the application of heat; and secondly, a small caravan was kept in the warehouse as an office/rest room for the workforce and electric power was laid on to this.

The drums of herbicide (200 litres) were stacked from floor to ceiling with wooden pallets in between each layer and it is thought that such wooden pallets contributed to the rapid spread of the fire. A further factor which played a large part in the spread of the fire was the presence of the octyl-phenols which had been deposited in the warehouse only the night before. When heated, octyl-phenols firstly melt, secondly ignite and thirdly will float on water whilst still burning. The two herbicides involved are non-flammable but when heated to decomposition can evolve highly toxic fumes.

On arrival the Fire Service were faced with a major fire giving off large quantities of toxic black smoke. Inside the warehouse the pallets were burning fiercely and the drums of herbicide, which consist of an outer steel drum with an inner plastic container, were boiling, bursting and toppling over as the pallets collapsed and leaking as the inner plastic linings melted in the heat.

At the application of foam was considered inappropriate in this case the fire was fought with water - in large quantities. The fire was put out by 12 noon but during the course of the fire-fighting it was later estimated that approximately 50,000 gallons to 100,000 gallons of herbicide, plus massive quantities of added water, had escaped from the warehouse. In the early stages of the incident efforts were made to prevent the diluted herbicide from entering the various suface water drains but this quickly became impossible owing to the quantities involved. The surface water drains both on the site and Quarry Lane itself connected directly with the culverted stream and the resulting serious pollution was later detected as far downstream as Snaith, near Goole.

The police activated Leeds City Council's Peacetime Emergency Plan and contacted other bodies. They also set up an incident room in a portakabin conveniently situated just inside the entrance gates to the premises. During the first few days immediately following the incident daily meetings of the various authorities and bodies were held in this incident room.

In view of the seriousness of the pollution the Water Authority requested the police to contact local radio stations, the press and television stations to warn the general public of the danger to humans and to livestock of coming into contact with the stream. Downstream users and abstractors (including power stations, collieries, chemical works and horticulturalists) were warned of the pollution and the potential hazards. This resulted in the closing down for a short time of N.C.B. pits and a power station. A regular monitoring of the stream was commenced to enable Y.W.A. staff to trace the extent and levels of pollution.

In view of the emissions of toxic smoke and the (at that time) unknown effects of the release of large quantities of herbicide in the environment, the police initially advised residents to remain in their houses and to keep doors and windows closed. Fortunately the smoke from the fire was blown in a north-westerly direction over open land and no dwellings were affected.

A problem which did affect residents whose houses face onto Quarry Lane was a stream of contaminated liquor several feet wide which gushed down the road gutter within three feet of their house walls. This was eventually overcome by bridging the stream of effluent with pallets from the company's premises. A large proportion of the contaminated flood water swept across the firm's car park, through a small screen of birch trees and down the valley into the no man's land between the properties in Quarry Lane and Woodkirk Gardens (see appendix). This flood water eventually overflowed from the valley into the rear gardens of the above properties onto lawns, flowerbeds and in at least one case into a greenhouse.

Although the fire was extinguished by 12 noon the Fire Service continued damping down within the warehouse and also hosing down the contaminated road surfaces both inside and outside the site. Arrangements were also made to hose down all vehicles leaving the site. As the Fire Service water demand was high it was considered that there was a possibility of the pumps creating a negative pressure in the water mains. Consequently there was a remote possibility that the mains water could have become contaminated from herbicides seeping from the road surface or from surface water drains. Accordingly it was decided that all domestic supplies in the immediate area would be cut off (approximately 150 houses) until the high water demand had ceased and sampling/analysis had shown that no contamination had occurred. The Y.W.A. also arranged for bowsers to provide supplies of drinking water in the area for the duration of the emergency. In the event, all mains water samples proved negative and piped supplies to the houses were restored by the late evening of Tuesday 16th i.e. approximately 84 hours after the incident.

Attending on site during the first two days were representatives from the Police, the Fire Service, the Y.W.A., Environmental Health Officers from Leeds City Council, Universal Freight staff, I.C.I. advisors, the local M.P. and local Councillors.

THE IMMEDIATE AFTERMATH

This Department's immediate concern in the first few days following the incident was generally to minimise further contamination of the environment and in particular to remove any immediate risk to local residents.

A sand bund wall was placed around the damaged warehouse to contain any further spillages. A second bund wall was laid across the entrance to the premises, thus preventing any further flow of chemicals into Quarry Lane. This bund diverted any remaining dribble of fluids from the site onto the already severely contaminated car park where it was considered that additional contamination would be of no significance.

The surface of Quarry Lane was then repeatedly hosed down and swept by one of the Department's mechanical roadsweepers. Following the sweeping, samples taken indicated very low levels of herbicide.

The cellars of the cottages fronting onto Quarry Lane had been checked and it was found that no flood water had entered the properties.

The severely affected land to the rear of the houses was fenced off to keep children and pets out and warning signs were erected both on this fence and alongside the contaminated stream.

PUBLIC REACTION

The area affected by the incident was already represented by an active Residents' Action Group which had previously campaigned vigorously against various planning applications in the area and in particular against proposals to establish waste disposal sites and toxic waste treatment plants in disused quarries to the west of the UFO site. Understandably there was a great deal of public alarm at the time of and immediately following the fire. The mere mention of paraquat evokes references to "the poison with no known antidote" and "the poison often used in suicides".

Very little information as to the toxicity of diquat and paraquat is readily available and officers had to rely on information from ICI chemists, ecologists and toxicologists. Quite naturally members of the public were a little dubious that the source of this information was, as they saw it, the opposition - the cause of the problem. Consequently the officers were faced with the unenviable task of convincing residents that the chemicals were after all herbicides and would obviously damage vegetation but this did not mean that there was a risk to human and animal health.

The M.P. for the area and local Councillors suggested that a public meeting be held in the local church on the evening of Monday 15th February i.e. two days after the incident. Officers of the various emergency services and local authority department outlined the action taken to date and their proposals for dealing with the situation over the next few days. They were subjected to close questioning from members of the action group and general public. In particular residents wanted to know whether the Company were in breach of any planning conditions attached to their premises or of any other legislation relating to the storage of the offending chemicals.

Planning Officers advised the meeting that they were not in breach of any planning conditions which would have materially affected the outcome of the fire. The Health & Safety Executive Inspector informed residents that he was aware of the materials stored in the warehouse but that the storage of the chemicals was not in contravention of any legislation and that the cause of the disaster was completely unforeseen i.e. a fire. The action group was not satisfied with this and claimed that they had always maintained that something like this incident could occur and the officers were negligent in allowing the Company to establish itself in close proximity to dwellings.

The media gave full national coverage to the incident and, even though this died down as matters improved during March, there was an upsurge in interest when plants began to show evidence of damage in late March and April. Two environmental action sheets were issued jointly by the two environmental health departments involved during the period April/May. These informed residents of the progress of action taken to clear the site, of results of samples taken and gave advice on the consumption of vegetables and fruit grown in the area. Nevertheless the public were not sufficiently reassured and demanded a further public meeting to enable them to put specific questions to officers, ICI advisors, etc.

The meeting was held on the 20th May, once again in the local church. This meeting later became known amongst officers at Leeds as the "Paraquat Pie Meeting". On the day of the meeting the two authorities had arranged for a toxicologist employed by MAFF to visit the area, inspect the damaged vegetation and attend the meeting so as to give an independent opinion to residents. He came to the same conclusions as had the ICI specialist, namely that although the plants had been damaged there was no risk to health and in particular, although the leaves of rhubarb plants had been very badly damaged, the stalks were quite safe to eat.

The meeting was chaired by the Leader of the West Yorkshire Metropolitan County Council, who called on officers, ICI specialists and the MAFF toxicologist to give their opinions on the damage to vegetation. The residents clearly did not accept the advice of the experts and they then played their trump card. In the full glare of television lights they produced several rhubarb pies together with severely damaged leaves allegedly previously attached to the rhubarb in the pies. The Chairman, officers and experts were all then invited to put their stomachs where their mouths were and eat the pies. Keeping our fingers crossed that the pies had not been deliberately "doctored" we ate the pies in front of the T.V. cameras. Thankfully no one suffered any ill effects and the Chairman, who had the remainder of his pie analysed later, announced that the County Analyst advised him that although traces of diquat were found in the rhubarb pie he would have had to have eaten 500 pies to have suffered any ill effects.

REMEDIAL WORKS

On the Monday following the fire, specialist ICI teams were drafted in to deal with the chaos inside the warehouse. Damaged and undamaged drums were balanced precariously on top of each other with burnt and collapsing pallets between each layer. The outer shells of the drums of diquat are constructed with weepholes in the bottom in order to detect leaks in the inner plastic drum and, as the heat of the fire had ruptured the inner drums, the contents had escaped via these weepholes leaving many of the drums empty. Other drums had become distorted in the heat and were very difficult to deal with.

Tankers were brought in to suck out the contents of all but the undamaged drums and this liquor was then returned to the ICI works at Huddersfield for treatment. The empty damaged drums were then crushed on site and removed to the ICI approved waste disposal site. The ICI teams, wearing heavy duty protective clothing, including gloves and protective headgear with a vizor to avoid splashes of chemicals reaching the face, took almost a month to work their way through the jumble of drums and other detritus in the warehouse. However, no further contamination was allowed to escape and that operation went smoothly.

In order to dilute the chemicals in the stream the Y.W.A. carried out a programme of flushing firstly the culvert and later the stream with copious quantities of cold water. However, this did not have the desired effect on the levels of herbicide at the outlet from the culvert, which remained steady at approximately 4,000 p.p.m. It was concluded that leachate from surrounding contaminated land was entering the surface water drains and the culvert and maintaining this high level of contamination.

After the warehouse had been emptied completely it was noticed that the concrete floor was cracked and holed in places, and trial bore holes established that large voids existed under the warehouse. Accordingly a strip of concrete floor was removed. This exposed several large voids created by the brick kilns which had previously occupied the site. These voids were full of relatively concentrated herbicide. The liquid was pumped out on several occasions and the voids promptly filled up again. In the end all voids were filled with concrete to eliminate these reservoirs of pollution. After this, the levels of herbicide at the outlet to the culvert gradually dropped, reaching what was considered a safe level, i.e. 50 p.p.m. by the end of April 1982.

THE CONTINUING AFTERMATH

By mid-March the situation at Woodkirk was beginning to calm down and life for the residents had returned to normal. Officers of the various bodies involved were able to reflect that, despite all the fuss raised by the residents and the media, not one person or animal had been injured. True, some trees at the end of the company's car park and in the fenced-off area of land would certainly die, as their roots had been soaked in strong concentrations of herbicide and some gardens had suffered damage following the flooding at the time of the fire. However, all the problems were by no means over - in fact some were just beginning.

Firstly, a housewife reported that she had suffered soreness of the hands after tending her garden some two or three weeks after the incident. She had also noticed that some of her plants were showing discoloured spots. An investigation showed that in her garden there was indeed evidence of some form of airborne contamination - there being widespread necrotic areas on all types of plants especially in the vegetable garden at the rear.

The strange feature of this occurrence was that the house in question is situated to the east side of the A 653, being number 1164 Leeds Road (see appendix). However, on questioning the lady closely, it transpired that on the day of the fire large quantities of foam had been blown into her garden from the stream to the south of her property. This is the stream which was receiving the contaminated water from the culvert and the Y.W.A. confirmed that on the day in question foam had been formed on the surface of the stream.

ICI chemists also interviewed the lady and inspected the garden. They agreed that the spotting of the plants could have been caused by contact with foam contaminated by diquat or paraquat and took samples of the affected plants and garden soil for analysis. The results later confirmed that diquat was present in leaves at levels varying from 0.05 p.p.m. to 0.55 p.p.m. and in the garden soil the level was 0.25 p.p.m. The ICI chemist stated that this was very low and was much lower than the concentration used in fields when applying weedkillers. Nevertheless this incident was reported to the press and gave rise to such banner headlines as, "WEEPING POISON WATER PERIL - WOMAN GARDENER FIRST CASUALTY". She was the first and last as it turned out.

As no other garden was exhibiting evidence of plant damage and there seemed to be a logical explanation for this particular damage, officers considered that this was an isolated case and assured residents that there was no further cause for alarm. Unfortunately this proved not to be the case! The weather, as usual, was not very helpful - in February, when one might have expected some co-operation by way of heavy rainfall which would have washed off any contaminated surfaces, it was drier than normal. The drier than normal February was then followed by a dry and windy March - as it turned out the worst possible combination of circumstances from the point of view of pollution prevention.

The Department began to receive complaints of plant damage in late March following a particularly windy spell and it is significant that during that spell the winds were predominantly from the west i.e. from the UFO site towards the dwellings in Quarry Lane and Woodkirk Gardens. It soon became evident that there was widespread airborne pollution - in one case up to half a mile downwind. The evidence was similar to that seen in the previous case - widespread spotting of plants of all kinds; in particular rhubarb plants suffered severe damage to the leaves. The most likely explanation of this wave of pollution was that the diquat and paraquat had formed crystals while drying out of various surfaces within and without the UFO site, and these crystals had become airborne in the strong winds.

It is thought that rhubarb leaves suffered particularly severe damage because the convoluted surface of rhubarb leaves must have trapped relatively large quantities of crystals which would then attack the leaves in the presence of water - even dew would be sufficient. Whatever the method of attack there was no doubt about the results. The flesh of the leaves was eaten away completely, leaving only the open "veins" and leaves resembling lace curtains.

Quite understandably the residents were alarmed by this clear evidence of airborne contamination and in addition some claimed to have experienced a prickling sensation on the skin of the face when out of doors.

In view of this new development a meeting was held between E.H.O.s of both Leeds and Kirklees, the Leeds M.O.H. and a toxicologist and an ecologist from ICI. It was accepted that the analysis of previously taken samples indicated that the plant damage was due to contamination from diquat/paraquat. However, the concentrations were very low and did not constitute a threat to health. Nevertheless in view of the public concern it was proposed that the following action would be taken:-

1. Samples of air/contaminants to be taken.
2. Samples of dust etc. to be taken from a variety of

surfaces within the UFO site and the Company to be pressed to clean up and/or replace material if found to be necessary.

3. The surface of Quarry Lane to be fully cleansed.
4. Boxes of broad-leafed plants to be set out in the area on a weekly basis to monitor the extent of contamination.
5. The two local authorities to prepare jointly a press release in order to explain the present position and hopefully to allay the understandable public fears.

Milipore filters were set up in the Company's premises and in a resident's garage - the results indicated very low concentrations of diquat in air. Samples taken at various points within the UFO site indicated that high levels of contamination still existed and the Company were requested by letter to carry out a thorough damping down and cleaning of the site. Some rather ineffective steps were taken to comply with this request but eventually, with the evidence of fresh contamination continuing, the Department was obliged to serve a notice under the provisions of Section 1 of the Public Health (Recurring Nuisances) Act 1969 on the Company. The notice stipulated that the following works be executed:-

Forthwith - Effectively damp down and cleanse the site so as to minimise emissions of all particulate matter.

Within 14 days - Remove all contaminated materials from the site and/or take such steps as are necessary to effectively abate the nuisance and prevent a recurrence.

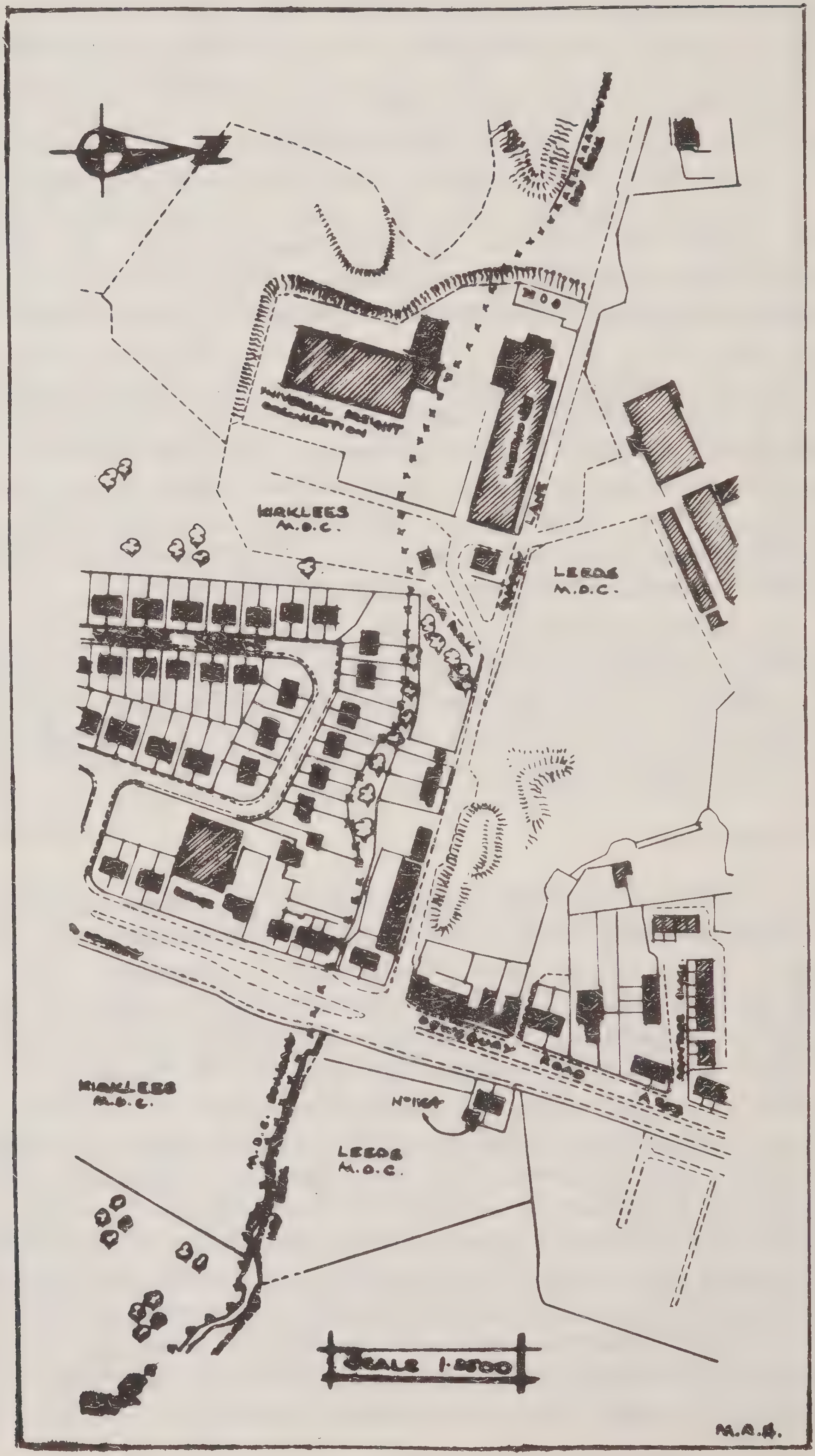
This notice was complied with and the affected areas were re-sampled. The contamination was found to have dropped dramatically. At the same time the test boxes of lettuces placed out in the open indicated decreasing levels of windborne contamination and all evidence of such contamination ceased by the middle of June. In addition, by then almost all of the affected plants in the residents' gardens (including the rhubarb) had recovered.

There was one further emission of pollution before matters finally settled down. In late June the heavy February rains finally arrived and during one tropical downpour, which lasted over 24 hours, the UFO site became flooded and the flood waters cascaded through the car park, into the fenced-off area of land and re-flooded the previously damaged gardens with contamination it had picked up on the way. A further complication on this occasion which caused consternation amongst the residents was that the floodwaters had a distinctly fluorescent blue colour. This merely indicated the presence of diquat monopyridone which is produced by the action of sunlight on diquat in water and which has a much lower toxicity than diquat. This phenomenon has occurred once or twice since that time, even as recently as May this year. This indicates that heavy rain is still likely to leach out diquat products from the most severely affected parts of the site.

This year (1983) almost all the vegetation appears to be growing normally without any evidence of last year's contamination. The only exceptions to this are the dead trees in the UFO site and in the still fenced-off area of no man's land.

CONCLUSIONS

It is unlikely that all environmental hazards can be anticipated. Responses can, generally, be made to an incident which cater for all immediate demands. The environmental health officer has a role to play in providing assistance in certain incidents but he does this as a member of a team. No single procedural document can cope with the possible range of events which can occur but experience should be used to refine and improve the system. It is, however, possible that by bringing together a series of case studies, such as that included in this paper, a document could be produced which would make local experience available nationally. Such a task could not be undertaken by a single local authority but could be the subject of a paper by the Department of the Environment, the Health and Safety Executive or some other government agency.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ANNUAL CONFERENCE – TORQUAY
31 OCTOBER – 3 NOVEMBER 1983

50th CONFERENCE
PART TWO
Report of Discussions

NATIONAL SOCIETY FOR CLEAN AIR
136 NORTH STREET
BRIGHTON BN1 1RG
ENGLAND

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PRESIDENTIAL ADDRESS

Professor D G.T. Williams

It is abundantly clear from the preprints of the papers for the 50th Annual Conference of the National Society for Clean Air that its concern for the environment extends far beyond a narrow concept of clean air as reflected in our domestic legislation. The topics raised in these papers - such as acid rain, control of process odours, aspects of the control of noise, problems associated with offensive trades, safeguards against major hazards in industry - illustrate the wide remit which the Society has now assumed. The regular publication of _Clean Air_ also adds to the same impression of wide ranging activity and action.

The significance of this wide remit is underlined by the demise in the past few years of the Clean Air Council, the Noise Advisory Council and the Commission on Energy and the Environment. It is certainly not my intention, on this occasion, to enter into a debate about QUANGOs, a term which, as you are all doubtless aware, inaccurately encompasses so-called Quasi Autonomous Non-Governmental Organisations. However, to speak, as one member of Parliament has done, of this country allowing quangocracy to threaten her Parliamentary democracy is surely to obscure, certainly in the context of advisory bodies, the positive democratic advantage of injecting an independent element into the process of administration.

The Society, of course, is not a government-appointed body and it is not funded by government but it occupies a unique position somewhere between an official advisory body and a private pressure group, achieving its special authority by virtue of the nature of its membership. It is charged (in an expansive sense) with the task of seeking the improvement of the environment. The importance of the Society's role is enhanced, may I suggest, by the demise of some of the official advisory bodies and is demonstrated in the increasing environmental consciousness of ordinary people everywhere.

One need hardly remind this audience of the mounting complexity of environmental concerns and environmental controls. Looked at principally from a lawyer's standpoint the evidence is overwhelming. In Italy recently we have seen the conclusion of a five month criminal trial arising from the disastrous dioxin fallout near Seveso in July 1976. In the United States, with its different legal background, its greater reliance on detailed regulations and its politically very sensitive Environmental Protection Agency, an out of court settlement was reached early in 1983 on what promised to be a very lengthy case indeed involving the manufacturers and the operators of the nuclear plant on Three Mile Island. Both parties agreed that it would be counterproductive to incur the substantial costs of further litigation. By contrast, it is in the United States that the completion of the TELEKO dam in Tennessee was blocked for several years, in part because of fears for the survival of a three inch fish of the perch family known as the snail darter.

Another dam featured very recently in one of the biggest Australian constitutional cases ever, over work begun on the Gordon River in Tasmania by the State's Hydro-Electric Commission. By four votes to three, the High Court of Australia a few months ago ruled that the Federal Government was empowered, on environmental grounds, to stop the scheme for the Franklin dam. In New Zealand, an attempt has been made in the courts to stop the employment of new stream-lined procedures related to plans for aluminium smelter works near Dunedin, litigation in part inspired by a body called Coalition for Rational Economic Environmental Development in New Zealand. One of the judges in the court of appeal noted that environmental law now rightly occupies a special and

important part in our legal system. In Scotland a lady, who lived in a flat at the corner of the Castle Esplanade in Edinburgh, this year won an interdict against some of the noisy preparations for next year's Military Tatoo, with Lord Stott at the Court of Session commenting that:
"Lord Denning's suggestion, in an English case, that an Englishman's home is no longer his castle cannot in my opinion apply to a Scotswoman's flat."

Also in Scotland there was the case on fluoride which far outshone other cases on fluoride anywhere in the world. An action brought by an elderly lady against Strathclyde Regional Council concluded this year after 201 days with over 143 volumes of evidence totalling over 5 million words and an eventual judgement of 392 pages. Even when the trial had reached a mere 121 days we were told that it could be matched for soporific tedium only by a Festival fringe production of the complete Ibsen cycle in original Norwegian.

Now what, against that, is the true position of this country? Has environmental concern exposed a new vein of litigation? Hitherto, the tendency would seem to be against recourse to the courts. Recent research on the impact of the Industrial Revolution on the law of tort for example, especially the tort of nuisance in the 19th century, suggests that the influence of the courts of law was slight, not because the techniques were absent but because, to a great extent, the Industrial Revolution happened before this country had wakened and was equipped to respond to its adverse consequences. Even today it is suggested that the Common Law of nuisance can at best play a subsidiary role in any system of pollution control having as its objective general social welfare.

Of course there has been a burgeoning of legislation since the mid 19th century effectively supplanting the ordinary common law, starting with the Alkali Act of 1863. But even with the rapid growth of controlling legislation associated with the public health aspects of pollution, the courts have been involved to a surprisingly small extent - largely because of a policy applied notably by the Alkali and Clean Air Inspectorate to use persuasion rather than punitive methods of control. This is based on the belief that traditional concepts of the criminal law are not readily applicable to the majority of infringements in this sort of area and indeed the Royal Commission on Environmental Pollution in its 5th report agreed, with respect to the work of the Alkali Inspectorate, that the policy of persuasion and co-operation was to be preferred to an aggressive policy of confrontation.

Nevertheless, looking at the environmental areas as a whole, there are signs of a change. Perhaps it is far too early to judge the cases on noise because environmental health officers are struggling to come to terms with the Control of Pollution Act in this area, although it is sad to be reminded of one case in 1979 where a noise abatement order was served over the activities of Patrick, a pedigree bantam cockerel and a family pet, who had been subject to a dawn watch by an environmental health officer who later testified as to Patrick's crowing - as he put it: "a piercing noise, strident and shrill", and the court gave Patrick seven days to leave town. There are occasional air pollution cases, including the litigation in 1980 when two oil companies were sued over lead additives to petrol - unsuccessfully because the defendants had in fact complied with the regulations under the Control of the Pollution Act. Some cases, of course, are launched in order to dramatise or publicise an environmental grievance and the law in a sense is flexible enough to allow for that.

A more consistent environmental theme is evident in legal cases and allied procedures associated with the approval of major developments in industry: for example, the search for minerals, provision of motorways and the generation of power. The terrifying length of the fluoride case in Scotland is matched by the length of public local inquiries, to say nothing of possible subsequent proceedings in the courts into major developments. In July 1983 the Stansted inquiry concluded after 258 days and the Sizewell nuclear inquiry continues. The public inquiry into the National Coal Board's application to mine in the Vale of Belvoir lasted 84 days and the issues raised, we were told, ranged from the mating cycle of the mayfly to the possibility of a revolution in Saudi Arabia.

It is worth bearing in mind that the inflationary cycle, with regard to public inquiries, is quite new - certainly a product of the last 15 years and no more. When a public inquiry was held soon after the war into the highly contentious plans for establishing a new town in Stevenage, the entire proceedings occupied no more than two days. Amid discussion as to how to handle the so called big public inquiry nowadays, there is the further possibility, of course, of requirements emanating from Brussels about environmental impact assessments, a device which in the United States has generated considerable litigation. There is concern in this country, legitimate concern, that there could be increased litigation over environmental impact assessments. Certainly they are going to come in one form or another; whether they will involve the courts to any great extent remains to be seen.

All these processes raise the question: "Do we wish to involve the courts to a growing extent in environmental matters?" Obviously the courts are going to be involved from time to time in the appropriate criminal prosecution, despite a preference for persuasion in civil proceedings under the older common law, and again, where appropriate, as a boost or a backup to regulatory powers now allowed under statute like a Control of Pollution Act. And the rapidly expanding area of administrative law has to embrace aspects of environmental regulation as well as a host of administrative powers in a vast number of contexts. One New Zealand practitioner, who has written a major study on environmental law has commented, on a system very like ours, that the role of the courts for the protection of the environment remains of crucial importance, notwithstanding the modern statute-orientated style of environmental regulations.

Now, in saying all of this, I would not wish to appear at all to be urging more recourse to the courts or to legal processes akin to those in the courts. On the contrary, there is much to be said for curtailing the length of hearings, either in the courts or in public inquiries, for no one gains (least of all the ordinary citizen) when proceedings become bogged down in the welter of arguments about policy considerations, technical and scientific data, and sites for specific proposals. Yet, as one American commentator has noted, the ordinary citizen may turn to a public hearing, in the courts or elsewhere, as the means of ventilating his grievances and frustrations.

We have been reminded often enough that modern government is large and complex and remote, and the highly centralised system in the United Kingdom is a prime example. It is incumbent I would have thought, upon politicians and officials, at local but especially central level, to seek mechanisms which can compensate for that size and complexity and remoteness and it is especially true in the sensitive areas of environmental concern. The laws on pollution, for instance, should be up to date and accessible. Some of our statutes might have appealed to the Roman Emperor Caligula, whose laws were written in fine print and then hung up on pillars too high for the ordinary passer-by to read. This Society and others have long called for a consolidation or where necessary an updating of the laws on clean air, and there is now the promise that this may take place.

More important, the statutory laws need constantly to be related to administrative controls exercised through planning procedures and other informal processes at central and local level. From such an attempt, it may be much easier to evaluate the need for putting informal processes, for example, on a statutory basis, through Parliamentary or subordinate legislation. We will also need to be reminded that frequent re-evaluation of our laws is necessary to prepare us for negotiations with our European partners, as Mr Tony Fairclough would certainly underline, or more widely in international negotiations over matters of common and environmental concern.

Now this may sound like a counsel of perfection, and I am well aware of the pressures on government and the understandable temptation to shelve troublesome schemes for the consolidation and reappraisal of laws. Moreover, the ramifications of any environmental policy are so wide that government often has to commit itself to the demands of the moment rather than to an overview of the problems of energy pollution, planning and environment. It is easier in practice for government to make an immediate decision on a specific issue such as lead in petrol, than to look at an entire area of environmental concern such as clean air, with a response to the Royal Commission's 5th Report taking six years.

One reason for the difficulty in securing an overview may simply be the understandable reluctance of government to commit itself to offer hostages to fortune in the volatile area of environmental concern: in other words, the environment, with its complex technical, scientific, economic, legal, social and political implications does not lend itself to decisions in the abstract. But if this is so, it is nevertheless necessary for government to ensure that there should, by some means, be a constant monitoring of the environment and a regular mechanism or series of mechanisms for offering guidance or reassurance to the public.

We have heard all too often that environmental pressures sometimes come from remote idealists and committed cranks; indeed, one leading United States' politician recently likened the environmental movement in the United States to the forces that created Nazism in Germany. Every movement has its cranks, of course, and it is true that the environmental movement has the vices as well as the virtues of novelty for many people. But it would be absurd to suggest that the revolution in attitudes which has occurred in recent years can be reversed. In good times and in bad, in periods of economic expansion and economic recession, there will be sustained pressure for the safeguarding of the environment and the manifestos of the political parties in the recent general election implicitly and explicitly accept that this is so.

In order to meet its obligations, any government must seek the best practicable environmental option in its policy on the environment. Apart from ensuring that basic research is maintained, government has to aim for the most satisfactory means of evaluating proposals for major developments. Above all, government has to aim for a regular monitoring of wider environmental issues, preferably by a machinery which blends an official input with an independent input. Quite simply, government should think again about advisory bodies charged with responsibilities which I believe cannot be satisfactorily performed by government alone.

The point is that the work of independent advisory bodies could, I stress could, because there are no absolutes in this field, be cost saving in environmental policy: the checks can be provided for major decision making, as for example the 6th Report of the Royal Commission was used in the Windscale inquiry. As for the Commission on Energy in the Environment, Lord Nathan said in a House of Lords debate earlier this year that such a body on a permanent basis would indeed help to clarify the broader policy issues at stake in, say, such an inquiry as Sizewell. He added that in his view the public needed to be provided with information from an independent source upon which it itself can reach a judgement, or at least understand the factors involved and the options available.

One can argue further that the existence of several advisory bodies with different remits and different services could justify much more rigorous controls on the length of public inquiries, and of course might defuse some of the feelings of frustration which leads individuals and groups, sometimes in an eccentric fashion, to seek recourse to the courts in what can be very expensive, time-consuming and delaying litigation.

Meanwhile, while we await some solution to what is essentially a democratic, constitutional problem of providing this kind of background for our decision-making, a body such as the National Society for Clean Air continues its advocacy of all reasonable methods of securing a cleaner environment and it offers within its sphere many of the advantages of official advisory bodies. It remains as a very important model. Its work has extended throughout this century and it will certainly extend into the next and in its commitment as a body, the National Society is one that is designed to make a better world for those who will be here a hundred years hence or five hundred years hence. Its task, as Lady McIntosh stressed two years ago, is to educate and motivate the people of this country in its own area. The Society reminds us of the value of independent, informed groups in the formation of policy. Such groups demonstrate, in a very modest way, a very quiet way, that, to quote the words of John Bright in 1846:
"There is in public opinion a power much greater than that residing in any particular form of government."

SESSION TWO

AIR POLLUTION CONTROL IN THE UK

THE WAY WE WERE - Audio Visual
NSCA

PRESENT ACHIEVEMENTS: FUTURE REQUIREMENTS
W F Snow, Chief Environmental Health Officer,
Warrington Borough Council

PANEL DISCUSSION
L M Rutterford, Department of the Environment
Dr L E Reed, HM Chief Industrial Air Pollution Inspector
A J Fairclough, Commission of the European Communities
R R Martindale, Confederation of British Industry

MR I W BARKER (Sheffield MBC) opened the discussion by saying that 1983 appeared to be a vintage year for marking anniversaries. It was the occasion of the 50th Conference, and reference had been made to Mr Snow's 25 years in environmental health. However, 1983 also marked another notable anniversary in the annals of clean air history. Twenty-five years previously, in March 1958, the Dark Smoke (Permitted Periods) Regulations had first come into operation. To those at the 50th Conference who looked forward to the advent of the 21st century that was a notable anniversary, since the Dark Smoke (Permitted Periods) Regulations had been based on the concept of allowing smoke to be emitted, rather than on the concept of eliminating smoke. Twenty-five years ago that permissiveness had been reasonable and practicable, but as we approached the 21st century, it was necessary to ask whether this was still a reasonable concept or whether we should now be seeking to amend the regulations, bring them into line with modern technology, and to seek a prohibition on any emission of smoke.

He felt this to be particularly relevant in view of the renaissance of coal as the nation's primary energy source and the difficulties that coal-fired furnaces had had in the past in meeting the permitted periods regulations. Some incentive was now required in order to bring coal burning into the 21st century, to compete on equal terms with oil and gas in the total elimination and prohibition of smoke emission.

MR A J FAIRCLOUGH said that, as a Brussels bureaucrat, he was a little reluctant to comment on peculiarly British regulations, which were after all the responsibility of the UK itself and not of Brussels directly. What normally happened in Brussels was to establish, in consultation with the ten member states, directives which laid obligations on the ten member states, who then had to take the necessary action within their own systems and by their own methods.

On a more general level, he said that he would like to comment on the suggestion that an approach which, twenty-five years ago had been based on allowing something to happen, ought now perhaps to be based on prevention. In that context, he thought that the Community's Third Environmental Action Programme, which had been unanimously agreed by the Council of Ministers and adopted in February 1983, contained some very flat-footed statements. It was a general programme, and did not list a whole series of actions to be undertaken, but rather set a framework for the approach for the future. One of its loud and clear proclamations was that in the future, prevention rather than cure should be the rule. Naturally, it also made other statements, such as that in these difficult economic times account had to be taken of the economic implications.... etc; however, Mr Fairclough thought that it was most significant that, after many years of talking about the desirability of a preventative approach - or as the Germans called it, "a precautionary approach", or as the OECD termed it, "an anticipatory approach" - here, as a statement of Community policy, this clear obligation was set out.

He had two related, general (but still important) background points to make. First, that there was a recognition that, as the Environment Programme put it, "the resources of the environment are the basis of, but also constitute the limits to, further economic and social development" of all kinds. He felt this to be an important recognition that environmental resources were society's resources for the future. That had been made plain in the presentation of the Society's policy that morning: the Society had been involved in trying to promote that policy, and there it was, enshrined in Community policy.

In parallel was the recognition that environmental policy had from henceforth to be regarded as a structural policy - i.e. as one of the central core of Community policies, and which, as the Programme put it, "must be pursued without regard to the short-term fluctuations in cyclical conditions i.e. irrespective of economic ups and downs. Mr Fairclough of course recognised that one could never totally discount the influence of economic difficulties; but he thought it was most important that a commitment had been entered into by the UK Government, along with the governments of other member states, that the intention should be to pursue environmental policy as a central element in all economic and social activity. It should not be regarded as a policy where action could be put off when times were hard. The protection of the environment would no longer be regarded as a luxury, to be pursued when money was available but dropped when economic times became difficult. It was now regarded as essential.

Such concepts would underlie the proposals made by the Commission of the European Community and would be backed by a degree of commitment from the individual member states' governments, with, importantly, the backing of head of states and governments, in the form of the declaration at the Stuttgart Summit in 1983. This, Mr Fairclough described as a very blunt declaration about "the urgent necessity of accelerating and reinforcing action at national, community, and international level aimed at combatting the pollution of the environment". There had been no such strong political commitment, at that level, since the Community's Environment Programme was launched ten years before. It was therefore very significant, and he was pleased that Mr Snow had referred to it. Although nothing was guaranteed in detail, Mr Fairclough thought that there was now an ambience which favoured prevention and recognised the urgent need to take action; and which also recognised that there would be economic consequences, which had to be faced and dealt with.

DR L E REED said that the Dark Smoke (Permitted Periods) Regulations had been introduced at a time when the combustion of coal was more widespread and primitive methods, such as hand-firing of boilers, were often employed. However, he thought that to talk of regulations which required the complete elimination of smoke was perhaps an ideal, but impracticable. It was sensible that when any regulation was 25 years old, it needed looking at to see whether it could be updated. This was particularly important in an area such as combustion control where technology had advanced considerably in recent years.

MR S CARDEN (Barnsley MDC) had a question concerning the review of the Clean Air Acts with specific reference to a particular local problem in Barnsley. He asked Mr Rutterford, first, if he could confirm that a review of clean air legislation was in fact being undertaken, and if so, what the timetable for the review was, and when new legislation could be expected.

One of the very many pollution problems faced by his local authority was the night-time burning of buses and other vehicles in order to recover metal. Because of the difficulty of proving that the emission was a dark smoke, at night time, it was impossible to secure convictions under Section I of the 1968 Clean Air Act. Householders who lived near to the large complex of scrapyards were unwilling to give evidence to prove that a statutory nuisance existed, and so the burning continued without restriction. Mr Carden asked Mr Rutterford whether he would take steps to close this loophole, by removing the need to prove "dark smoke", perhaps introducing instead an absolute offence, similar to that which already existed for cable burning.

Referring to the pre-print of Mr Brookfield's paper, which had touched on the problem of night-time burning, Mr Carden wished to support Mr Brookfield's call for new legislation. He emphasised the need for urgency; in his area, ratepayers were suffering, complaints were being made and there was no solution to the problem at law.

MR L RUTTERFORD confirmed that, as the Government's response to the Royal Commission's 5th Report had made clear, DOE were committed to conduct a review of air pollution control legislation, and that would certainly encompass the Clean Air Acts. As far as the timescale of the review was concerned, Mr Rutterford admitted to some difficulty. He said that his (Air/Noise) Division were very hard-pressed; air pollution generally was in a very lively state, not only in the context of the Clean Air Acts, but in the far wider international context, as the number of issues to be discussed at the Conference bore witness to. All he could say was that they regarded the review as a matter of some urgency, and were pressing ahead with it as quickly as they could. He hoped that it would be possible to produce a consultation paper on the issues by about the Spring of 1984. He did not feel that they could do better than that, and whether they could do as well as that would depend on the other demands on their resources. However, he quite took the point that Mr Carden had made about the problem of night-time bus burning. He was rather surprised at the impossibility of persuading local residents to give evidence so that action could be taken against the nuisance of the smoke - but recognised that there must be aspects of the problem that he had not so far appreciated.

MR BYROM LEES (Individual Member) proposed to speak on his speciality, oil-firing, adding that he considered that oil-firing in industry would continue for many years to come. Turning first to the problem of acidic smut emission, Mr Lees said that he had first worked on this problem twenty years before as leader of a BP team; they had reduced the problem by insulating chimneys. The first had been at the Daisy Damp Wash Laundry, Portsmouth, and the system had since been adopted throughout Britain (including by the CEGB) in Europe, Australia, the United States of America, and other parts of the world. However, when they had first started, they had met with considerable resistance because of extra initial expense and progress had initially been slow. The solution was now embodied in a British Standard.

The second problem associated with oil-firing was the emission of acid particulates (as well as acid smuts) from the boiler. The problem was particularly noticeable first thing in the morning when the air purge took place: acid particulates were emitted and fell out locally. These were separate particulates, not bonded particulates like acid smuts. The 1971 Grit and Dust Regulations' requirement for oil-fired plant was that emission of unburnt solids must be less than 0.4 per cent of the fuel consumed. That was a comparatively easy standard to meet, compared with legislation in other European countries. The standard applied to boilers with a capacity of less than 40,000 tons of steam per hour. Mr Lees said that those in the audience would know, as well as he did, that the standard was simply not being met, despite the fact that the regulations specified that seven years after they came into effect (ie in 1978) all boilers should meet the standard.

He and his colleagues in BP, in collaboration with Max Beaumont, had developed a gas-solids collector to overcome this problem. It was a type of cyclone which operated with low-pressure loss - less than 2 inches water gauge, 5 millibars. Gas-solids collectors were not widely accepted in Britain, largely because they involved some capital expenditure. However, one had been installed in Guernsey to operate on a diesel-fired CHP unit, with a partial by-pass system. The partial by-pass was open for much of the operating period so that the pressure loss across the system was only a half-inch water gauge, 1 millibar maximum. The cyclone unit was only used at maximum throughput during periods when the plant was emitting an excessive amount of unburnt solids. Thus, with an oil-fired boiler, for example, the collector would probably be operated without the partial by-pass only during the air purge period in the morning when emission of high acidic particulates was excessive.

When they had introduced insulated chimneys, they had not called for support from local authorities. Operators had been prepared to install the insulation themselves because the life of the chimney was increased in addition to the reduction in or elimination of the acidic smut emission. However, the new gas solids collector units did not have similar secondary benefits. The support of local authorities and the Industrial Air Pollution Inspectorate was required to ensure that operators installed proper arrestment equipment in order to meet the 1971 regulations, with oil-fired plant.

MR W F SNOW, replying, said that (as he had mentioned in his paper) were Central Government to give local authorities the money and resources to allow them to appoint sufficient staff to carry out the monitoring, the local authorities would be only too pleased to do it. The problem in his own department was that he had had to take staff off pollution control and put them into housing - since they were under considerable and extensive pressure to get rid of the backlog of home improvement grant enquiries. With such limited resources, staff had to be used to the best of their ability in the most effective way. He said that he personally would be delighted to carry out more monitoring programmes and the only thing stopping him was lack of money and lack of staff.

DR L E REED agreed with Dr Lees that the 0.4 per cent emission limit for smaller oil-fired boilers was lax and its revision was overdue. However, he felt that central to the issue was what had happened to the oil industry over recent years. At the beginning of the 1970s, fuel oil had been the predominant fuel in the industrial market; to-day, however, that was no longer the case. Looking at current developments in the oil refining industry, less fuel oil was being produced, because the oil industry was extracting more of the higher grade products (such as petrol) from the barrel, thus decreasing the proportion of heavy fuel oil. Local Authorities would face probably a very limited number of new installations using fuel oil in the future; therefore the scope for fitting even simple collectors would be small. Those industries which came under the Inspectorate's control were the larger ones, where emission limits were more severe.

MR R MARTINDALE referred to page 3 of Mr Snow's paper (which in most respects he had found attractive). At the top of that page, Mr Snow had highlighted the fact that people must be prepared to pay; what Mr Martindale felt had emerged from one or two of the questions was that there was less will amongst the general public to pay in order to resolve some local issues. He thought that this was because people recognised that, in being prepared to pay for pollution control, there might be a concomitant loss in employment in the area, as well as the actual economic cost. Those factors influenced the local authorities, in terms of availability of resources. The crucial point was what the public were prepared to pay, in view of the substantial improvements in air quality which had been achieved during the century, as highlighted in the NSCA audio-visual. In general, he felt that people recognised the scale of these improvements, while acknowledging that in some particular cases control was less than satisfactory.

DR REED felt that it was important to differentiate between existing, and new, plant. As a pollution control authority, the Inspectorate would not, he emphasised, reduce its requirements for pollution control on new works in the hope that it might help to create employment. If that were to be done, the public would be landed with a plant which would be sub-standard for the next twenty or thirty years. Therefore, on new plant the Inspectorate had standards which it intended to enforce. On an existing works, there was a grey area, in respect of how far one could press for improvements when there were other demands for the resources available.

MR LEES pointed out that the gas solids collectors could and should be retrofitted on package boilers and other plant fired with fuel oil. Reducing atmospheric pollution required capital expenditure but the expenditure would benefit the nation. He did not accept restriction of expenditure as an excuse for not enforcing the 1971 Clean Air Act. He reminded the panel that there were more than 3 million unemployed, including many young people, so that shortage of man-power was also no excuse.

CLLR J ROONEY (Newtownabbey, Northern Ireland) congratulated Mr Snow for an excellent paper; he felt that it was one of the best he had read in its treatment of acid rain. However, he felt that Mr Snow could have looked further into the future and wished to take the opportunity himself to make some comments in that respect. Mr Rooney said that he was attending the Conference as a representative of his Council, but that he also spoke as a professional engineer in the energy field.

Three weeks previously, the Institute of Energy had held a conference on the effectiveness of fuel additives. Having studied the papers, which he had found most interesting, Mr Rooney concluded that fuel additives would play a major part in pollution control in the future. He reminded delegates that the emission of black smoke from industrial premises was a sign of incomplete combustion, representing a waste of energy and money. He felt that, with the high cost of energy, industry now realised that there were big savings to be made by cleaning smoke emissions, and hence the environment.

A case in point was a large power plant in Northern Ireland, where a magnesium based additive was injected into the flue gases (at a cost of £100,000 per annum). The additive allowed the dew point of the gases to drop sufficiently, thereby enabling additional heat recovery estimated at £400,000 to be achieved. Thus, there was a considerable monetary reward as a bonus for reducing acidic smut emissions.

In another case, in Spain, a large power plant sited near extensive orange groves, had each year to pay out considerable sums in compensation to the orange growers because of pollution fall-out on the crop. That plant, too, had used additives injected into the flue gas and had found it more economical than paying compensation and had at the same time improved public relations.

He felt that there was still considerable research to be done, but the prospects looked good, even in the use of coal as the major fuel. Already, copper sulphate had produced some interesting results with coal-fired boiler plants. At present it looked as though coal would play a more important part as a major fuel source in the future. Fluidized bed development had progressed well, although the system had not been widely applied as yet in the UK. One new development, called Ko-al was a mixture of pulverised coal, water and an additive, all of which would be pumped into the furnace. Encouraging progress had been made with this development in the United States.

But, returning to the subject of oil, Cllr Rooney said that one of the problems in relation to acid rain was that most of the good ("sweet") oil from the North Sea was exported to Europe. That was fine in economic terms, since the oil commanded a good price. Germany, for example, was prepared to pay that price, since they had set a limit of 0.5 per cent sulphur in fuel oil. In the UK, fuel oil containing 4 per cent sulphur was being burned. In Cllr Rooney's opinion, some of the money obtained from the sale of high quality oil from the North Sea should be creamed off and put into development. He asked the panel whether they would agree that more money should be put into research into the whole field of fuel combustion, with a view to improving the environment.

DR REED said that, in answer to the assertion that 4 per cent sulphur oil was being used in this country, that might be so in a few isolated cases, but his understanding was that the sulphur content of fuel oil in the UK had gone down appreciably following the introduction of a percentage of low-sulphur North Sea oil. Dr Reed agreed that there was considerable scope for improving efficiency in energy utilisation. Additives to improve fuel combustion had been in use for many years and, of course, additives to reduce dewpoint and prevent acidic smut emission were also well known. He was sure that they could help improve efficiency, and if this led to savings such as the £400,000 referred to on a particular combustion plant, then there was a strong economic incentive for their use. Dr Reed felt certain that industry was looking closely at ways of becoming more energy-efficient and hopefully, at the same time, by using less fuel, improving environmental conditions.

Dr Reed agreed that black smoke was a sign of obvious waste of energy, but considered that the occasions on which prolonged emission of black smoke could be seen were few and far between. He remarked that, looking around London, the only chimneys which could be seen regularly to emit black smoke were those serving the incinerators of London hospitals. There was, he felt, considerable scope for improvement there.

CLLR R KIDD (Newtownabbey BC) asked a question relating to the unforeseen effects of the introduction of smoke control. He accepted that smoke control areas had produced a great improvement in the atmospheric environment, but he was concerned about the fumes emitted from plant manufacturing solid smokeless fuel and the output from solid smokeless fires into the atmosphere. He wondered whether they had any effect on the health of people in the vicinity.

His second point related to the stated efficiencies of the various types of fuel for domestic heating purposes. Those were based on the fact that there was a slow air change within the room, in the order of one every eight hours, compared with the conventional open fire's three air changes every hour. An input of air equivalent to a hole of about 50 sq ins was sufficient for the fire, which was normally made up through ingress via faulty windows, defective doors and other draughts. In these to gas and electric appliances as well as the conventional coal fire, whether smokeless or not. In these discussions, no consideration was given to the amount of oxygen required by the occupant of the room; the only concern seemed to be the amount of oxygen the fire itself required. Mr Kidd wondered whether legislation was required to specify the proper type of ventilation in the home when such appliances were installed, bearing in mind, in particular, the air needs of people with heart and chest problems.

MR SNOW felt that the change from coal to solid smokeless fuel was, it could generally be agreed, a definite advantage. As far as the installation of solid fuel burning appliances in homes in new smoke control areas was concerned, he thought it most important that the applicant should seek, and be given, proper advice on such matters as ventilation. He knew that the Solid Fuel Advisory Service and the Solid Smokeless Fuels Federation offered considerable advice and help to such people. Most people were now very conscious of the need to insulate homes, and thus block out any draughts; the one advantage of the solid smokeless fuel appliance was that a reasonable rate of air change was achieved throughout the dwelling, which helped to overcome problems of condensation.

MR RUTTERFORD, referring to the question about the possible hazards to health posed by plants manufacturing solid smokeless fuel, said that smoke control itself had obviously brought benefits to health. As the audio-visual had shown, it had eradicated the problem of smog, although there was insufficient known about the actual component of smog which caused the most damage. One of those possible contributory components, sulphur dioxide, was certainly largely retained in solid smokeless fuel.

In relation to the question of ventilation and levels of pollution indoors, Mr Rutterford said that this subject was being more widely studied now. He suspected that this increasing interest had been prompted by the work of the European Commission, and the development of air quality standards in Europe, which drew attention to pollution levels in relation to health in the ambient atmosphere, but also directed attention to the levels of these pollutants which could be reached within the home. As the audience probably knew, levels of pollution within the home could substantially exceed those in the external air notably in terms of nitrogen dioxide levels - which was one of the subjects of a draft air quality standard. Attention was being directed to the conflict between the requirement for energy conservation, and the health requirement for adequate ventilation. He hoped that out of current work and research would come a better understanding of where the balance lay between the two requirements.

MR R F V AYLOTT (City of London) referred to one of the subjects mentioned in Mr Snow's paper, pollution from transport. The M25 - the London Orbital motorway - would shortly be completed and Mr Aylott thought that there would inevitably be pressure from certain speculators to develop some of the Green Belt around London. He felt that in view of recent comments by the Secretary of State for the Environment the Government might well be influenced by such pressures, and could in some instances give way and allow development to take place. He asked the panel to comment on the possible use of air pollution factors to resist the speculators' intentions at Public Inquiries. He was not aware that such criteria had ever been successfully used in resisting development in the past, or indeed in resisting the construction of major roads, but he wondered whether the panel could foresee, in that particular case, an opportunity for these factors to be adequately weighed in the balance.

MR RUTTERFORD thought it rather unlikely that air pollution factors could be advanced as a principal part of a case for resisting Green Belt developments. Other and stronger grounds would be needed - and were likely to be available - to stand up against the obvious economic advantages of such development.

MR MARTINDALE said that if such a battle could not be won on air pollution grounds, it surely could be won on some other, perhaps more substantial basis.

MR CARSON (Newport BC) first gave warning of his commitment as an environmental health officer. Twenty years previously, he had sought finances for equipment to monitor noise and vibration from a local quarry which was causing tremendous problems; the Borough Treasurer had, quite sincerely, said to him: "We never had any of this noise and vibration until you came along"! Mr Carson had gone on to invent acid rain in Newport, lead and cadmium emissions and problems with asbestos!

Major environmental problems still existed today. Mr Carson felt that even Mickey Mouse (President Reagan) admitted that acid rain had something to do with sulphur and nitrogen compounds. Mr Carson considered that the primary source of these compounds was major industrial installations. He asked the panel whether they would agree with his view that the success of local authorities in controlling smoke and SO_2 emissions via the Clean Air Acts was in stark contrast with the failure to control those same emissions from major installations.

Despite the excellent work that had been done by the Factory and (former) Alkali Inspectorates, they remained thin on the ground, grossly understaffed, grossly overworked and grossly unaccountable to the people in the community that suffered from the emissions of smoke and SO_2. He wondered whether the local authorities, on the strength of their past successes, should not take on more power to control emissions from major industrial installations.

MR MARTINDALE said that Mr Carson had contrasted the success over the last twenty years (in smoke control) with a failure (to control emissions from the major industrial installations) over a relatively shorter time. He himself would have put the timescale for smoke control achievements in terms of a rather greater period. It had taken a very long time for people to recognise the problem, to come to terms with the fact that it was something that could be resolved, and put the remedy into effect. He felt that it was important to consider the whole timescale in relation to Mr Carson's analysis.

In contrast, with acid rain, the problems had been studied for only the last ten years or so. There was recognition that problems existed, but the stage had not yet been reached where the way forward, to resolve the problem, could clearly be identified. When it came to the point where a decision could be made to take a course of action that was recognisably sensible, then perhaps action could be taken more quickly than had been the case with the implementation of smoke control. Thus, overall, the analysis of the problem and the solution could take place in considerably less than the 100 years or so that smoke control had taken to achieve.

He argued that the analysis, seen in those terms, had nothing to do with the other possible factor that Mr Carson had identified, the difference between central and local control of emissions. Indeed, he felt that where longer range, international problems were concerned, there was much to be said for dealing with the problem on a national rather than a local basis.

MR RUTTERFORD said that it was intrinsically wrong to refer to a failure to control smoke, certainly, and SO_2 from major industrial installations. Only with the benefit of hindsight was it possible to look at things in that way. For many years, the dispersal of sulphur dioxide had seemed a very reasonable control strategy, not only in the UK but in many other countries. Using this technique, acceptable ground level concentrations of smoke and SO_2 had been achieved. For that reason, apart from one or two areas where smoke - from domestic premises - was still a problem, the UK was within the limits specified in the EC Directive (Health Protection Standards for Smoke and SO_2). The long-range transboundary component of the problem had only relatively recently been recognised, and was clearly one to be tackled in the future.

The point about central versus local control of pollution was invariably raised. Mr Rutterford felt that power stations provided an outstanding example of the case for central control, via the Industrial Air Pollution Inspectorate, rather than the different approaches of various local authorities. In terms of a possible control requirement applying to national emissions of SO_2, he felt there was a very strong case for a national basis of control that the Central Inspectorate could provide.

DR REED felt that Mr Carson had claimed a great deal of credit for local authorities in the control of smoke and sulphur dioxide. While this may have been true for smoke, in respect of sulphur dioxide, he felt that any success was largely fortuitous. Without the discovery of North Sea gas at the time when the smoke control programme was gaining momentum, the present improvement in air quality would not have been achieved. Had North Sea gas been used in major industrial or power-generating plants, reductions in the emissions of SO_2 from those installations would have resulted, but without much effect on air quality. However, that would have been a short-sighted policy. By using North Sea gas mainly for the domestic market, the population benefitted by a reduction of both smoke and SO_2 levels.

Dr Reed said that there were times when he would be entirely happy to hand over to local authorities the control of one or two major plants. However, he doubted whether local authorities would have any greater success with controlling emissions from those particular plants than the Inspectorate. He felt that air pollution control split between Central and local Government was a sensible arrangement and this had been endorsed by the Royal Commission on Environmental Pollution. The powers available to local authorities were inadequate and ways of improving them were being explored. He also felt that there was greater scope for moving more easily processes from Central to local control and vice versa. He stressed, however, that whatever the legislation, it was most important that both local and Central agencies worked together in controlling pollution for the benefit of the public.

MR FAIRCLOUGH, referring to the question of acid rain (or acid deposition, as he preferred to call it, since both solid and wet deposition were involved) wanted to clear up any possible misunderstanding caused by Mr Martindale's reference to 100 year and 20 year timescales. The Commission of the European Community had already made plain that it regarded the problem of acid deposition as an urgent one. At a Symposium in September in Karlsruhe, which had attempted to assess what was known, a former Dutch Minister, in summing up the findings of the symposium, had said: "Measures have to be taken now"; and he had made plain his view that the fact that we lack scientific certainty in certain areas should no longer be regarded as an adequate justification for inaction – "there is no time any more for such reasonings". The Commission, Mr Fairclough said, was committed to making proposals for emission limits for large combustion installations before the next Environment Council meeting on 28th November 1983. Thus, from the Commission's standpoint, the acid deposition problem was seen as an urgent one, where action was urgently needed, and where enough was known to make sensible policy proposals. Of course, he could not comment on what the Council of

Ministers would make of the proposals; nor on how long the negotiations would go on.

MR SNOW felt that the Conference had looked back enough that morning, and should be looking forward to the solutions to current problems. The resolution of the acid rain problem would require the commitment of individual governments and organisations to ensure that the achievements which could be made, would be made within a reasonable timescale. Mr Snow felt it would be wrong to talk of a timescale of twenty years to solve the problem of acid rain; he was sure that it could be solved in a much shorter period.

Referring to remarks made about HM Air Pollution Inspectorate, he felt it fair to say that they were overworked and understaffed. He thought it a pity that the Inspectorate, which had such major responsibilities, (some of which were shared by local authorities) should considered inaccessible by the general public because the inspectors were so thin on the ground and so widely spread. As a result, it was the local authorities that received the complaints. His own department maintained very good liaison with the local industrial air pollution inspector, with day-to-day basis contact on certain problems, and they exchanged information. Nevertheless, Mr Snow felt there was a need for greater resources to be provided to the Inspectorate.

SESSION THREE

ACID RAIN

ECOLOGICAL EFFECTS: FORESTS AND SOILS

Dr W O Binns, Forestry Commission

ECOLOGICAL EFFECTS - WATERCOURSES AND FISH

Dr D J J Kinsman, Freshwater Biological Association

INTERNATIONAL ASPECTS AND UK POLICY

L M Rutterford, Department of the Environment

DR R A BARNES (Esso Petroleum PLC), opening the discussion, asked the audience to stand back from parochial issues and consider the implications of the draft EEC directives (to which reference had already been made) upon people in the areas represented by delegates at the Conference. Amongst those implications were a potential increase in energy costs, a possible increase in the price of motor vehicles and a general increase in the cost of motoring.

Many of the Community proposals were based upon the controversial forestry damage, which occurred almost exclusively in the Federal Republic of Germany. There was, certainly, damage in other parts of Europe, notably in Eastern Europe, but this was due to the phototoxicity of sulphur dioxide. Mention had also been made of nitrogen oxides and the resultant formation of nitrates in the atmosphere. Having attended several important meetings on the subject in recent years, and in 1983 in particular, Dr Barnes understood that nitrogen oxides and nitrates were not, on the whole, particularly significant in terms of ecological damage, except where NO_2 and SO_2 were present in fairly high concentrations and acted synergistically on growing plants. In remote ecosystems, where growing rates were nitrogen-limited, nitrate could indeed in some ways be beneficial. Dr Barnes therefore asked Dr Kinsman and Dr Binns if they would comment on the direct significance of current NO_x emissions on fresh water and forestry.

Looking at the papers independently, Dr Barnes said that he had been most reassured to hear that the symptoms which had been found in the Federal Republic of Germany did not appear to be occurring in the United Kingdom. However, he sought Dr Binns' opinion on the significance of UK emissions on the dieback that had been observed in German forests, and also, whether he regarded drought as a significant factor in that dieback. Drought had been mentioned in a number of recent cases; an interesting review from North America, where apparently pine and spruce dieback had also been observed as early as the 19th century before industrial emissions affected the forests, suggested that there could be a correlation between years of accumulated soil moisture deficit and the onset, two or three years later, of forest dieback. Europe, of course, had been subject to a very major drought in 1976, just three years before the Germans had begun to observe the same effect.

Turning to Dr Kinsman's paper, which had highlighted the effects of increasing acidic deposition in remote receptors as having a fairly well established effect on freshwater ecosystems, Dr Barnes wondered whether the effects that were now being observed in parts of the United Kingdom, notably in Wales, Cumbria and Scotland, were new. Certainly, such effects had been established in Scandinavia for some time, but he wondered whether such effects were now being found in the United Kingdom because they were being sought, whereas previously they might have gone unnoticed. Should Dr Kinsman reply that those effects were indeed new, then Dr Barnes wondered whether he would attempt to explain how they had occurred when the UK's emissions of sulphur dioxide had fallen by 30% in the past decade. Dr Barnes asked whether Dr Kinsman might suggest that the UK was suffering trans-boundary pollution from the continental mainland. Finally, he asked Dr Kinsman whether he would care to comment on the role of deposition of acidic sulphate - sulphuric acid - into a catchment, vis-a-vis the deposition of neutral sulphate. In his presentation, Dr Kinsman had talked almost exclusively about hydrogen ion input to a catchment, whereas it had been Dr Barnes' understanding that, because of the ion exchange which took place in the predominantly acidic soils of those sensitive catchments, it was the deposition of total sulphate that was important.

Turning finally to Mr Rutterford's paper, Dr Barnes said that he had been reassured to find that the DOE's policy very much reflected that of industry and of wise people generally. In effect, that action should be taken to protect the environment, and indeed, to improve it, but that any investment should, essentially, be made in areas where cost-beneift could be maximised. Dr Barnes shared Mr Rutterford's lack of assurance that some of the recent and anticipated EEC initiatives would meet that criterion. Dr Barnes wished to ask Mr Rutterford a slightly theoretical question: whether, were the UK and the rest of Europe to be burdened with the rather crude device of sulphur dioxide emission control as a requirement of the Commission, (and her Majesty's Government, as an agent of the Commission, would be responsible for implementing such directives within the United Kingdom) the Government would take into account that, currently two-thirds of the relevant emissions were derived from just one hundred sites, which discharged high in the atmosphere. Quite often (more often than not indeed) the discharge occurred above the mixing layer and therefore contributed disproportionately to transboundary air pollution. Alternatively, he wondered whether the Government would favour a policy of equal misery for all.

DR BINNS, replying on the point about UK emissions' contribution to damage in West Germany, said that his understanding of the published data was that the track of UK emissions did not, by and large, go to the areas of West Germany affected by forest dieback. He said that perhaps Dr Keddie, who was present in the audience, would be able to confirm this.

Turning to Dr Barnes' second point about the possible effects of drought on forest dieback, Dr Binns felt that it was impossible to say whether or not it was a coincidence that the reduction in growth now being observed in trees appeared to have started in the late 1970s, although the damage, in spruce at any rate, had not been noticed until 1979 or 1980. It could well be that drought had contributed to the problem; in his opinion, any form of stress on a tree or any other plant would reduce its resistance to other forms of stress. Whether that stress was drought, frost, ozone damage, or whatever, it would increase the tree's susceptibility to any other stress that occurred - which might even be a beetle or a fungus. The factors affecting tree damage were complex and Dr Binns would certainly not rule out the possibility that the 1976 drought had, in some areas at least, sensitized trees to other forms of damage later on.

The North American view was that much of the damage observed there was due to long-term drought effects. A case of widespread dieback in yellow birch in North America had been studied; the eventual conclusion, after all the possible causes had been considered, was that drought had been the main triggering agent.

DR KINSMAN, replying to the question on nitrogen input into environments, said that fresh water ecosystems were only very occasionally nitrogen-limited. They were generally phosphorous-limited; thus, excess nitrogen input would not normally have a significant effect. In any event, agricultural activities were a major source of nitrogen/nitrates input into freshwater ecosystems, as was the centralisation and development of large sewage plants. The latter had resulted in the input of ever increasing amounts of nitrate into some of the UK's larger rivers and lakes. Thus, atmospheric emissions played only a small part in relation to the much larger input of other sources of nitrates to freshwater ecosystems.

On the question of whether the effects observed in parts of the UK were really new, or only new in the sense that they had not been noticed before, Dr Kinsman said that no-one had made observations in many of the remote parts of, for example, the Lake District, until quite recently. Very few good scientific observations had been made until quite recently on, for example, the chemistry of upland streams. Now, people were going out with portable pH meters or pond nets, to look for the presence or absence of organisms: finding a stream without fish, such observers sounded the alarm. Rarely, however, was there proper evidence that there had been fish present in previous years in waters now lacking fish. Thus, Dr Kinsman felt that Dr Barnes' comments had highlighted a very real problem. In just a few instances, it was known that there had been changes. In some Welsh streams, there had definitely been reductions in fish, according to work done by the Welsh Water Authority.

On the question of the deposition of sulphuric acid versus the deposition of neutral sulphate, Dr Kinsman thought it was mainly a problem of what went on in soil profiles. He had referred to hydrogen because there were no environmental effects in the aquatic environment related to sulphur excess. Essentially, sulphur was never limiting in the fresh-water environment and sulphate ion was no problem as it was ionised and balanced by a positive ion such as hydrogen.

DR BINNS, answering the point about the impact of nitrogen on forests, said that there was no doubt that nitrogen had been seen to have impacts on forest growth. In contrast to fresh waters, nitrogen was often a limiting nutrient in forest ecosystems, more particularly in continental forests where there was snow and frost in the winter. In the milder uplands of the UK, there had been (since the ice cleared from the land after the last ice age) a gradual loss of phosphate over the millenia in the reducing conditions during wet winters. In the uplands in the west of the UK, straight phosphate fertiliser was frequently applied to grasslands, because of the overriding phosphate deficiency.

However, that was not so, by and large, in the mineral soils of central Europe where nitrogen was a limiting nutrient. In fact, in S Germany, they had observed increased growth rates over the last 20 years in all the control (i.e. untreated) plots in their forest fertilizing experiments (there might, of course, also be climatic factors). The Scandinavians, and Ulrich of Göttingen, feared that if this trend continued, there would be a super-saturation of nitrogen; and there might be enough nitrate formed to cause leaching, so that acidification would worsen.

MR RUTTERFORD interpreted Dr Barnes' questions as being that, if there were to be a requirement on the UK and other members of the EEC for a given reduction in emissions, how would that be apportioned amongst the polluting sources. On the principle of equal misery, he said he could give no clear judgement. It would, he felt, take the wisdom of Solomon to decide what would be equal misery in such circumstances. The obvious course of action would be to look at the major sources, those where sulphur removal technology could be most easily applied, but it would obviously be a very complex matter to decide the best strategy in those circumstances. He did not think his department had yet examined the question in sufficient detail to give a more positive answer than that.

MR N H PARKINSON (Selby District Council) said that in his view, if the UK were to take seriously its responsibility for reducing SO_2 emissions in both the national and international context, there was no need to spend several years debating and researching the starting point. There was no need to look further than our own modern coal-fired power stations. Prior to the early 1960s, most UK power generation had been from 150-500 MW power stations served by low chimney stacks, from which, consequently, sulphur dioxide and other pollutions were emitted at low level. Now, typically, power generation was centred on 2,000-4,000 MW power stations with high-level chimney stacks of between 600 and 850 feet. Ground-level concentrations of sulphur dioxide around power stations were consequently relatively low. However, he asked whether it was more than a coincidence that, 20 to 25 years after introducing the tall stack policy, parts of the UK and Europe were now beginning to react to the clear evidence of the retardation of forest growth and the depletion of freshwater fish stocks. Although DOE and the CEGB were not yet satisfied that UK power stations' emissions were contributing significantly to the problem of acid rain, a recent Parliamentary reply had stated that 63% of UK sulphur emissions came from power stations, with other industry accounting for 26% of total fuel-derived emissions, while domestic sources contributed just 6%. Mr Parkinson believed that, in real terms, nearly 1.5 million tonnes of sulphur dioxide and about ¾ million tonnes of nitrogen oxides were emitted annually from the high-stack coal-fired power stations.

The Ayr Valley Power Stations of West and North Yorkshire alone would burn 20 million tonnes of coal per annum over the next 30 years. On the completion of Drax power station 600,000 tonnes of SO_2 would be emitted annually into the atmosphere from that group of power stations. Were desulphurisation eventually to be introduced, it could have far-reaching consequences for the local environment in the Selby area. There could be an additional 1.8 million tonnes of waste to be disposed of annually were conventional flue gas desulphurisation to be required, to meet European Community legislation, in addition to the annual 4 million tonnes of power station precipitator waste that was already being disposed of, and would be for the next 40 years. Mr Parkinson asked Mr Rutterford whether any future EEC directive on the subject would include desulphurisation of flue gases at existing power stations; and if so, over what sort of time-scale would he envisage the requirement being implemented.

MR RUTTERFORD said that he had already referred to the draft EEC directive on the control of the emissions from combustion plant; it had yet to emerge into the Council machinery, so that its exact terms were not yet known. Mr Rutterford thought that it would almost certainly be couched in terms of specific levels of emissions that had to be achieved, and would probably not specify the technology for achieving these levels. However, FGD might well be needed to meet the stated reductions in emission levels. Mr Fairclough might be in a better position to comment more accurately on the specific proposals. In addition, he thought that there would be some reference to the application of the proposals to existing power stations. Were the emission limit to be based on the German ordinance, the EEC proposals would call for the installation of control equipment within a timescale that would, to some extent, and logically enough, depend on the likely future life of the station. The proposals would not be simple, but sufficiently complex to allow existing stations to carry on without control if they were due to come out of service within a relatively short time. However, Mr Rutterford said that to decide what would be a reasonable period in which to carry out such controls, implied some judgement as to the wisdom of taking such a step at this time. He did not really regard that case as having yet been made.

DR L E REED (HM Industrial Air Pollution Inspectorate) said that his question was really to Dr Binns and he thought that it had been partially answered by other speakers. Some five years previously, when the UN ECE Convention on Trans-boundary Air Pollution was being developed (and he had been very much involved in those negotiations) there had then been no hint from the Federal Republic of Germany of any possible damage to their environment caused by transboundary air pollution. Yet, within three years, their Minister had come to the 1982 Stockholm Conference, speaking passionately about the damage to German forests and the need for all other countries to institute controls similar to those being imposed upon German industry. Dr Reed's point was that there had been very little change in the emission of sulphur and nitrogen compounds for the last decade or so;

there had probably been no changes in the precursors for ozone formation. In other words, all the pollutants had been present for the last ten years or more. He asked whether it was likely that the damage had become suddenly evident in the course of one year and, if so, what had caused it, or whether it was possible that, because the Germans had not been looking for the damage, it had been developing over a long period and suddenly been discovered.

DR BINNS said that that was a fair comment, and that the Forestry Commission had asked exactly the same question of their German colleagues. He himself had visited some high elevation forests in North East Bavaria in 1975 and observed a small amount of needle yellowing of the spruce trees, which the Germans had attributed to magnesium deficiency. He remembered that well because he had been surprised and had asked for confirmation of their diagnosis, which they had given. There had been no suggestion of any serious damage - he had seen no dead or seriously damaged trees.

Whatever the politicians, or any particular lobby, were doing or saying about the situation, Dr Binns was quite certain that the German researchers, whom he knew well, would not have missed the symptoms that were now there to be seen at high elevation. Returning to the letter by Dr Kenneth Mellanby, to which he had referred during his presentation (The Times, Wednesday October 26th 1983), he said that it was quite clear that damage was restricted to trees at higher elevations (CEGB figures for ozone damage were for 1200 metres in the Black Forest, which was quite high). Most such areas were not primary production forest, they were part protection but they were used and harvested. When he had visited those areas in 1982, his and his colleague's examination of damaged stands, including trees cut down, had suggested that growth reduction (i.e. reduced annual height increment) had begun in the late 1970s. In one stand, in the north of the Black Forest, they had found a lot of damaged trees, some of which had recovered and were now growing normally, some of which still showed stunted growth, and some of which had died. The onset of the damage was traced back some four or five years, i.e. to 1977/78. Dr Binns said that it was normal for a tree's height growth to vary from year to year, but if the tree were to grow poorly for two or three years, then a forester would begin to feel concerned. Were the needles to go yellow and start falling off, the forester would get very concerned indeed. That last stage had only been reached two years previously, and he believed that it was a new symptom.

As for explanations, he had laid on the table all the contributory causes he could think of. There had, for example, been some very sudden, severe frosts. High ozone levels had been recorded in those elevated areas, but, as Dr Kinsman had pointed out, there was no historical record of levels of ozone over the years, so it was impossible to say whether the levels recorded were higher than in earlier years or not. There were many holes in the jigsaw, but he did believe that the phenomenon was new and was sufficiently widespread to be worrying. It was impossible to tell whether the problem would right itself on its own, or even whether it would get better if nitrogen and sulphur dioxide emissions were to be reduced.

CLLR L HARRISON (Wakefield MDC), referring to fluidized bed developments, mentioned the installation at Grimethorpe which had proved so successful in reducing emissions. However, he pointed out that it would be a mistake to assume that the air was generally clean, at least in his part of Yorkshire. Because of the lack of any pressing incentive, either by way of money or strict national standards, smoke control was not being implemented in the Wakefield area. There were various problems that had to be overcome, to which he had made reference at the NSCA's Sheffield Workshop and Llandudno Conference, including the miners' concessionary coal allowance. Without intending any disrespect, he felt it would be helpful if those who worked within central government, in the Air Pollution Division, should perhaps be required to move to the most polluted areas of the country and experience first-hand what it was like to breathe a less than pure atmosphere.

Cllr Harrison made a plea, first, for national standards to be rigidly enforced and second, for an educational programme, perhaps devised and sponsored by the National Society for Clean Air, to be available for use in areas such as his own. That would help to overcome any antagonism towards clean air policies. Having talked to a friend, formerly the local vicar, who had moved down to a place near Torquay two years before, he realised that one of the most striking differences between the north and the south was the age at which people died. In the north, death often occurred at around the age of 50 or 55, whereas in the Torquay area, a lifespan of 80 or 90 years seemed common.

MR J H BODDY (Individual Member, NSCA) said that it was very apparent that the pollution control legislation of the EEC was largely based on circumstantial evidence. He referred to Dr Binns' paper and quoted the following extract relating to the deterioration of trees: "the decline is in areas where the pollution levels, as judged by concentrations of SO_2, are relatively low." Mr Boddy's conclusion was that, on the face of this evidence, a power station in the area of the forest might provide the solution to the problem rather than EEC legislation to reduce SO_2. He was concerned that the pressure for introducing new pollution control legislation came largely from the headline writers of the popular press, and asked Mr Rutterford whether those in government departments could be protected from the pressure wielded by such headline writers who advised politicians what they thought the public wanted.

Mr Boddy said he strongly supported proposals for further research into the problems of acid rain. He wondered whether it would be possible for the National Society for Clean Air to make some contribution to this effort – not necessarily by funding research directly, but possibly by running some sort of scheme to obtain subscriptions which could be used to sponsor research.

MR RUTTERFORD was grateful for the expression of sympathy towards those government departments which were under pressure from headline writers, but felt that there was no ready solution to the problem. Civil servants were there as the servants of the Ministers, and it was the Ministers who responded to the pressures from the media, and in turn the civil servants had to try to meet the Ministers' requirements. As Dr Binns remarked, "better that than Pravda".

Mr Rutterford did not think that he could properly comment on the role that NSCA might have in forwarding research.

MR B LEES (Individual Member) said that Mr Rutterford had detailed, very precisely, the extent of knowledge on the causes and effects of acid rain. However, Mr Lees thought that his statement regarding support for research into emission control and new technology "having as its aim the development of less costly techniques" was vague. Wondering whether Mr Rutterford had been referring to flue-gas desulphurisation, Mr Lees pointed out that Lord Flowers, at the recent Royal Society of Arts Conference, had called FGD "the billion-dollar solution to the million-dollar problem". Mr Lees said that flue-gas desulphurisation had been applied in Britain, at Fulham, Battersea and Bankside Power Stations. Latterly, it had been widely studied in USA, Germany and Japan. He felt that any further research conducted in the UK would take at least ten years and would be of questionable value. He wondered if Mr Rutterford had been referring to other techniques, and if so, which. As a supplementary, Mr Lees asked whether magnesium salts' deficiencies were important.

MR RUTTERFORD said that he had not been referring to FGD which, as Mr Lees had suggested, was a fairly commercially available engineered system. There was possibly scope for improvement, but the technique did basically exist. The Government had in mind the development of alternative, less costly, and perhaps more elegant techniques. After all, FGD systems themselves posed environmental problems, in terms of obtaining limestone, transporting it, and disposing of the waste slurry. DOE and the Department of Energy were beginning to discuss and explore alternative control techniques with the CEGB and others. One possibility was the development of the low NO_x burner - the use of special burners which reduced emissions of NO_x, the action depending on the fact that those emissions were substantially dependent on temperature. That process might facilitate the use of direct limestone injection into the furnace, at the combustion stage, rather than, as with FGD, injecting limestone into the flue-gases before emission.

The central point was that, under the UK system of control, requiring best practicable means to be used, the object was to achieve a balance between the costs of control and the advantages from control in any situation. The more that low cost, effective routes to control could be found, the easier it would be to contemplate tightening the emission control requirements.

DR D LAXEN (Greater London Council, Air Pollution Group) wished to follow up certain points made by Mr Rutterford in his presentation. It was noted that Dr Binns had pointed out that ozone was now strongly implicated in the forest dieback in Germany. Ozone was also of some importance in Britain. Each summer, large areas of the UK experienced episodes during which the concentration of ozone exceeded the 80 ppb standard, set to protect sensitive crops and plants. Dr Laxen explained that ozone was a secondary pollutant, resulting from photochemical reactions involving hydrocarbons and oxides of nitrogen. He therefore wished to ask Mr Rutterford whether he would agree that it would now be prudent to introduce (further) emission controls for these pollutants. Such a move would have the additional benefit of reducing acid deposition due to nitric acid;

it would also reduce roadside NO_2 levels, for which a draft EC directive was currently under consideration.

MR RUTTERFORD said that there were already measures to reduce emissions of hydrocarbons and nitrogen oxides from road vehicles. Agreement upon a new level of control had been reached at the last Environment Council, and the new control would come into force in 1986. The questioner had implied that there was a need to go much further with such controls, and if that were so then the most obvious route seemed to be the three-way catalytic converter, an option which involved additional cost (to the motorist) in the order of several hundred pounds per vehicle. Energy costs were also entailed; and there were serious doubts about the effectiveness of converters, especially under European driving conditions. This was an option which the West Germans had considered adopting, in connection with the removal of lead from petrol - since the removal of lead was a necessary preliminary to the use of such catalysts. Again, Mr Rutterford felt that the question of cost-benefit arose. The costs involved in going down that particular route to secure further emission reductions were very large. The UK would certainly require a great deal more information about the benefit side of the equation before committing themselves to that method of control.

There did, however, seem to be other options for reducing emissions from road vehicles, particularly by engine re-design, which would also offer other advantages.

Referring to the possible role of oxidants in tree damage, Dr Keddie said that there was some evidence to suggest that transboundary transport of oxidants was more important. The figures he had quoted for sulphur deposition might not, therefore, apply to oxidant transport.

DR A W C KEDDIE (Warren Spring Laboratory) took up the point made earlier by Dr Binns on the proportional contribution of UK emissions to the German problem. In relation to acid deposition, Dr Keddie thought it important to point out that the relative contributions (from one country to another) were not simply a function of the prevailing winds, but also depended strongly on emissions within the particular (affected) country and the emissions in the immediate neighbouring countries. The Federal Republic of Germany did not lie in the path of the prevailing wind direction as far as the UK was concerned, and had very substantial emissions of its own.

Dr Keddie said that the UK contributed about 5% of the sulphur deposition over the Federal Republic of Germany. To put that figure into context, he said that it was estimated that the UK contributed 15-20% of the sulphur deposition in south west Scandinavia. The main reasons for the difference were the difference in the prevailing winds, and the fact that indigenous Scandinavian emissions were considerably lower than in West Germany. It was currently estimated that the UK itself contributed between 75% and 80% of sulphur deposition within the UK, accounting for some 25% to 30% of UK emissions of SO_2.

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SESSION FOUR - PART 1

DEVELOPMENTS IN THE MEASUREMENT AND CONTROL OF PROCESS ODOURS

Dr R L Moss, Warren Spring Laboratory

MR J J BEAGLE (London and South East Division) asked whether, in spite of the major technological advances in qualifying and quantifying odours, the human olfactory organ (i.e. the nose) still had a major part to play in the assessment of odours, or whether, in time, it would be superseded by sophisticated man-made sensors.

MR W F SNOW (Chairman) referred to an experience six years earlier in Warrington, when a new process of engraving rubber rollers, using lasers, had been introduced in the area. That had resulted in the emission of burnt rubber to the atmosphere, which had caused considerable ill feeling amongst residents living in houses only 20 or 30 yards away from the works' site. Warren Spring Laboratory had been brought in, and had given much helpful advice on the problem. The Company had spent quite a bit of money, using scrubbers and activated carbon filters etc. One suggested solution had been a stack approximately 97 to 125 feet high, in order to disperse the odours. Fortunately, before the Company could be involved in that sort of expenditure, information had been received from Germany about a solution to the process odour, involving the use of cyclone filters in conjunction with a drum paper filter, with the resultant gases being passed through carbon filters. That had been applied in Warrington, with 100% success. In fact, the exhaust air was in the end so clean that it was eventually pumped back into the factory. All this was achieved at a fraction of the cost that would have been involved in building the chimney.

MR C G HOWELL (NSCA, South West Division) asked Dr Moss whether he had any experience with odour problems resulting from the spray drying of food additives, in the form of hydrolised vegetable protein and yeast extract. Such a process was causing a nuisance in his neighbourhood; various control methods were under consideration: masking, incineration, adsorption and absorption. These methods were being evaluated by the firm and by the environmental health department. Currently, the firm was using a venturi scrubber, with a fairly low stack of about 16 metres and particulate carryover was occurring. So far, the Company had agreed to increase the stack height to 24 metres, and to endeavour to install a knitmesh droplet arrestor on the scrubber outlet. However, there were fears that it could become clogged and that plant failures would result.

In addition, an analysis of the offending constituents was to be carried out, with a view to adopting absorption techniques. Mr Howell asked for Dr Moss's comments on this type of process odour, and on any experience with droplet arrestors: in particular, their efficiency. He also asked whether Dr Moss considered that absorption techniques should be given priority in cases of this sort.

MR I W BARKER (Sheffield City Council) had found Dr Moss's paper most interesting and very practical. He himself had been out of the field of odour control practice for some years, and he had found it both interesting and perhaps reassuring to note that the techniques which had been used eight or nine years previously were still basically those in use today. In his own time as an enforcement officer, he had been an advocate of the use of catalytic afterburners, and he recalled one particular instance when he had advised their use in a case of odour from a textile finishing works - arising from a heat setting process. After a degree of pressure, and some persuasion, the company had installed the first catalytic afterburner in Leicester.

Initially, the control method had proved 100% successful, the odour being completely removed. However, the success had been short lived as the operational reliability of the afterburners rapidly diminished. After a period of some six weeks, the down time was something in the order of 50%. The reason for this was the entrainment of a considerable amount of lint in the exhaust gases, which impinged on the catalyst, not only clogging it, but also causing frequent fires. Mr Barker understood that similar problems occurred when using catalytic afterburners to deal with gas streams which had a high fat content. Therefore, he wished to ask Dr Moss whether these practical difficulties had been overcome in the intervening nine-year period.

His second question concerned the use of chemical scrubbers which had frequently been used when he had been a pollution control officer. One of the problems had been the high energy requirement for the scrubbers, which had resulted in a considerable additional cost. He asked Dr Moss whether the particularly high power requirement had been reduced in modern design.

MR G VULKAN (Greater London Council, Scientific Services Branch) said that the discussion had so far centred on odours from fixed industrial sources, but another problem existed: odours from traffic, particularly in heavily congested routes and in shopping centres. Traffic in these areas gave rise to a lot of complaints, not only about noise and air pollution, but about odours. Similarly, there were complaints of odours near airports. He asked whether any work had been done on the assessment of odours from traffic and airports, and whether any development work had been carried out on methods of reducing odour, particularly from diesel exhaust. He wondered whether it arose in diesel-engined vehicles because of bad maintenance, or whether there was a more substantial reason for the odour problem.

His second question concerned the olfactory panel (to assess odours) described by Dr Moss. Mr Vulkan said that it was well known that prolonged exposure to an odour effectively desensitized the nose. He asked whether that process of desensitization was taken into account in the assessment of the panel's judgement of odours.

DR R A HOOD (Travers Morgan Planning) said that he was involved in planning problems. Frequently he had to predict the subjective response to odours at the planning stage. There was a problem with using data from different laboratories throughout the world, but he had, lately, been struck by the gradual convergence of techniques used in the United States and the Netherlands. They both used a flow-rate of about 15-20 litres/min. They both used a presentation method of increasing concentrations. They also used something known as the "forced choice" method, which seemed to eliminate most of the subjective element of the respondent's reaction to the odour. He asked Dr Moss whether the WSL method of odour measurement was compatible with those on the Continent and in the United States.

Dr Hood's second question related to the interpretation of data. Odours varied in intensity: one odour would be malodorous at just above the detection level, whereas another would have to increase one-hundredfold above its detection level before it became malodorous. Some American researchers were concentrating on that aspect, by developing the "butanol referencing scale" which enabled them to assess the intensity of an odour. He asked whether WSL had evaluated that method, and if so, what their opinion of it was.

MR J P GOSS (London Borough of Ealing) asked Dr Moss to comment on the possible use of emission standards in relation to the control of odour particulates. He referred to a case which had involved the importation from USA of a second-hand machine for the lithographing of tinplate under heat conditions. A similar machine had been exported at the same time to West Germany, for use in the US parent company's firm in that country, and another had been exported to the Netherlands. In the Federal Republic of Germany, the plant was required to meet particulate emission standards, which it did.

Similar standards were applied to the plant in Holland. Again, those were met. In Britain, there were of course no standards for that type of particulate emission. The Environmental Health Department at Ealing had advised the company to set an arrestment plant in anticipation of nuisance. That warning had been given at the planning stage, and noted but otherwise not acted upon by the importers of the plant. Nevertheless, a severe odour nuisance had arisen and the local authority had served a recurring nuisance notice which had forced the company to install a packed tower scrubber which had abated the nuisance reasonably well.

In contrast, on the Continent, although the plants had met the emission limits' requirements, a nuisance was still being caused in both the Dutch and German case. But, unfortunately, as the plant had met the emission standards' requirements, the German authorities had been able to take no further action, and it had been left to local residents to seek some form of injunction.

Therefore, he asked for Dr Moss's comments both in relation to emission standards and whether, should such standards be set in the UK and met, the local authority would be prevented from taking any further action to deal with any nuisance which still arose.

DR MOSS, replying to the questions raised in the discussion, said that he had found the questions most interesting as they had touched not only on problems with which he had been concerned over the years but also on points of general philosophy, some of which he had tried to bring out in his presentations. For example, he would like to emphasise the importance of working back from the standard that had to be achieved to abate the nuisance for those people affected to the means for achieving the required degree of odour control.

Replying to Mr Beagle, Dr Moss said that capillary column chromatography could resolve nearly all the compounds present in the gas stream; by attaching an odour port to the outlet of the gas chromatograph, it was possible to determine which of those compounds was odorous and using mass spectrometry, it was possible to identify them. Obviously, such equipment would usually be too complicated to attach to the outlet of a process plant. However, plant operators still wanted a signal from some simpler device which would indicate whether or not what was being emitted would be likely to cause a nuisance. He thought that, in a few cases, the odour was primarily determined by one or two substances, hydrogen sulphide for example. In such cases it might be possible to develop a warning instrument based on the analysis of a few substances. He emphasised however, that this might only be done in some cases; in most instances, odour mixtures were too complicated and it was impossible to correlate odour measurements with analytical data. In the absence of regular odour strength measurements, plant operators had to rely on maintaining their odour abatement equipment within the pre-determined operating parameters.

Referring to Mr Snow's point, Dr Moss said that it was interesting to consider the use of cyclones in the abatement of odours. Most people thought of odours as only present in the gas-phase but in fact odours could also be carried on particles to the atmosphere and they then desorbed from the particles into the environment. Therefore, the installation of a cyclone or bag filter to remove particles could actually, in some cases, have a beneficial effect in reducing the odour. There was, of course, in the example quoted, a further stage, namely carbon filtration to adsorb malodorous substances still present in the gas-phase. This association of odour with particulate emissions would apply not only in the case of burnt rubber mentioned by Mr Snow, but also in such processes as animal food compounding where a certain amount of the odour was carried on the dust and the cyclones reduced the odour strength. Similarly, in animal rearing buildings where there was a lot of dust about, it was thought that in some cases removing the dust had an effect on the amount of odour emitted.

Referring to Mr Howell's question on spray driers and food additives, he said he could not make a recommendation since he did not know what the additives were, and the other factors involved in this individual problem. However, the question raised some general points in relation to the determination of stack height in such a case. When one was trying to make do with a moderate stack height, it was essential to have odour measurements, to determine the strength of the odour and also to measure the volume flow rate, from which the odour emission rate could be calculated and hence the required stack height. Only in some cases, for example, when dealing with solvent emission, where the amount of solvent being used could be established, was it possible to make an attempt at estimating odour strength. However, these were rare cases, and usually it was necessary to establish odour strength before fixing a stack height, for example, to dispense residual odour. Again, it was a question of working back from the desirable end result to an acceptable odour emission rate and hence, to the choice of technique for its abatement and the efficiency required.

On Mr Barker's point about catalytic afterburners, Dr Moss stressed the importance of trying out odour pollution control equipment on pilot scale before full-scale installation on the process plant, to see if there would be any such problems, e.g. lint clogging the catalysts or fat having the same effect. Expert advice and reference to any other relevant trials on the control application of catalytic afterburners envisaged were also useful. Catalysts were often protected by pre-filtration etc. but even if clogged or blinded it was not necessarily an irredeemable situation. Some catalysts, such as the metal ribbon type, could actually be taken out and washed (using the manufacturer's instructions). Often activity in other catalysts could also be restored. The main point was that there should have been pilot scale testing preferably supported by odour measurements and that there should not have been whole plant installation of the afterburner before such testing. In relation to

Mr Barker's second point, about the power requirements for scrubbers Dr Moss thought that possibly the power requirement could now be greater than formerly since, with the drive for greater efficiency in odour abatement, a series of scrubbers might be specified.
(NOTE ADDED IN PROOF: However, to keep matters in perspective, 'Odour Control - A Concise Guide', 1980 gives the energy costs for a two-stage chemical scrubber, preceded by a spray-scrubber as 15 pence per hour per 1000 scfm)

Referring to Mr Vulkan's question about odours from road and air transport, Dr Moss said that there was tremendous interest in the quantification and abatement of diesel odour in the United States, where about half the literature on odours appeared to be concerned with this problem, which might seem surprising in the UK where there was not, in proportion, the same interest in diesel odours compared with other odour problems. WSL had done work, some years previously, on diesel odours, to develop methods for odour assessment. They had been interested in the storage of diesel odour so as to be able to bring samples back in Tedlar bags from lorry exhausts under road conditions. They had shown that stored samples retained sufficient odour intensity to make adequate odour measurements. A new and interesting development was the WSL proportional exhaust gas sampling device, which could be fitted on the tail-pipe end of a car and could take samples under actual driving conditions, instead of on a roller dynamometer. Thus, a considerable amount of knowledge was being built up about petrol-engine emissions under actual car driving conditions. He hoped that a similar amount of knowledge could be built up for diesel emissions, including the amount of odour produced from different types and conditions of diesel-powered vehicles.

Dr Moss said that Dr Hood's questions related both to perceived odour intensity and detection threshold measurements. Measurements of the strength of odour against scales of butanol, or some other odorant were perceived odour intensity measurements. These had their uses, but were not those which WSL made, which were in fact detection threshold measurements. The 'forced-choice' was a sample presentation technique which could be used in threshold measurements. WSL asked their panellists to state whether or not an odour could be determined at a series of dilutions. On the question of desensitisation (asked by Mr Vulkan) Dr Moss said that their panellists were exposed to a supply of fresh air for 5 or ten seconds; the diluted odorous air stream was then fed through to the panellists for 15 seconds, after which they gave their vote. They might be asked to assess and vote in that way some six times in succession, and that was the end of the assessment. Panellists were only required to assess perhaps four samples within half an hour, then take a rest and do another four samples in the next half hour period, the total session lasting under two hours. Dr Moss said that there was no doubt that prolonged exposure to odorous air did desensitise the nose, but their panellists were exposed to the diluted odorous air for only fleeting seconds before making their assessment and therefore they did not become desensitised.

Referring to Dr Hood's question on the variation in the level at which an odour could be detected, Dr Moss said that it was well known that perceived intensity was a complicated function of odour concentration. It was sometimes necessary to increase the strength of the odour by a factor of ten to make a small difference in people's perception of the difference in the strength of the odour. In other cases, there was a very direct relationship between the concentration and the perceived intensity.

DR A W C KEDDIE (Warren Spring Laboratory) said that he would deal with the question of emission standards, and whether, should they be adopted in the UK, they would remove any grounds for complaint about nuisance.
Dr Keddie's understanding was that, even if such standards were introduced in the UK, there would still be redress under common law in the High Court against nuisance

suffered by individuals. Were the introduction of emission standards to be well tailored and thoroughly understood by all sides, then emission standards alone might be enough; nevertheless, a change to current legislation would be required. He believed that the Department of the Environment would be considering some of the ramifications of this problem in its review of the control of industrial air pollution.

From his experiences over the last 12 years, Dr Keddie felt that there was a case for more specific guidance to local authorities and industry than was provided at the present time in relation to odour and other environmental problems. He felt that such guidance would provide a better and more clearly understood basis for resolving many of the difficulties that arise.

SESSION FOUR - PART 2

STRAW AND STUBBLE BURNING - THE NSCA VIEW

Air Cdre. J Langston, Secretary General

It can be very bad psychology to start with an apology, but I feel that I should explain why you will not find the text of these words among the pre-prints of papers. However, because the programme had to be rearranged at such short notice I decided that the best I could do in the time would be to give you a copy of the letter on straw burning which we sent to the Minister (MAFF) on the 14 October which you will have found on your seats. As it includes a comprehensive statement of the Society's policy and embraces most of what I want to say this morning, I would be grateful if you would accept it as being one of the Part I Papers.

The Society has been looking at the pollution arising from straw and stubble burning for nigh on twenty years. It has got steadily worse. The long hot summer of 1976 produced one major episode which provoked much comment at the Annual Conference that year. Since then we have seen the growing impact of the Common Agricultural Policy on cereals growing with the result that the areas under cultivation are increasing year by year. Thus the problem is gradually accelerating. 1981 produced another major episode with the level of complaints rising in crescendo. As smoke obscured the motorways and smoke and smuts were reported in major urban centres so the media reported the growing public concern. In consequence the Society did two things: firstly we wrote to the Minister of Agriculture expressing our view that the farming industry should be subject to the same sort of controls as are imposed on all other industries. The reply, which was published in Clean Air, was so unsatisfactory that the Council called for a full re-examination of Society policy. This was duly completed and the following spring (of 1982) presented in written evidence to the Royal Commission on Environmental Pollution. As many will recall, this was also published in Clean Air. But although copied to MAFF and the NFU it made no apparent impact. The common response from both organisations was: that the industry had no alternative to burning surplus straw and clearing the stubbles; that the law was adequate; and that the best that could be done would be to tighten even further the NFU Code of Practice.

However, the NFU has gone on year by year tightening its Code to very little effect. With major pollution episodes arising from two out of the six previous harvests, your Council decided that more drastic action was called for and, to bring home the magnitude of the problem to the nation generally, the Society should first try to quantify it. The fact is that while everyone was aware of the problem, no-one had measured it nationally. For example, how many complaints were received by the local authorities, who made them, what was the impact of straw pollution on other industry, on the householder, on road traffic, and, indeed, on other farms? So we decided to set in hand a survey. Early this year we wrote to a number of local authorities throughout the country asking if they would like to participate. These authorities were selected on the basis that they had written to us in the first place, either individually or as members of a group, expressing concern about the problem. Altogether we invited some 40 authorities to take part and Warren Spring Laboratory most generously agreed to brief those wishing to take part on the technical requirements of a properly co-ordinated survey.

In the event, some 16 authorities agreed to participate and the Central Electricity Generating Board also agreed to provide any data recorded by its rural monitoring stations. For a lack of resources and other good reasons, several participants were unable to cover all the aspects of the survey, but even where they could only provide details of complaints even this level of information remains valuable and is extremely welcome. The results are only now beginning to reach our Brighton headquarters, and thus do not appear in the rather general survey which appears as the Annex to our letter to the Minister.

Once the survey got underway other authorities began to hear about it and expressed an interest in taking part. But as the splendid summer led on to an early harvest, and as the pollution spread over the countryside so the situation blew up. Suddenly we found ourselves besieged by numerous other authorities writing and telephoning about their local situation with many wishing to join in the survey. Indeed in the course of the last two months we have heard from numerous local authorities in 24 counties. In the course of three and a half weeks we received some 90 letters from the general public, many as a result of letters from the Society published in the national press. In addition, we received a continuing flow of clippings from local newspapers. From the number of requests we were receiving for interviews on local radio and television it finally became clear that 1983 was a record breaker. Had we known the extent of the pollution that was going to be generated by this third major episode within eight years, I would assure you that we would have started the survey much earlier putting more effort into it and perhaps getting more out of it. What started off as a pilot scheme by our 16 local authorities which would lead on to a bigger and better survey of the 1984 harvest was somewhat overtaken by events! My earlier point which I must now repeat, is that with three major episodes in eight years there is no reason to suppose that there will not be another next year or the year after that and/or the year after that -- and with tens of millions of people throughout the land (and you will know that I am not exaggerating) now being polluted by this monster of the straw burn - which is affecting their lives, their businesses, damaging their property and in many instances affecting their health - it has become abundantly clear that we must press for comprehensive and effective action for its control by the Government.

I have no doubt that Government will say that it is taking effective action. The Minister of Agriculture will repeat what his predecessor wrote to us two years ago - which you will see we have repeated in the letter in front of you. He will also say, as he said on the BBC only two months ago, that changing the law is not the answer. Now I am not trying to be emotive but the fact is that the Minister of Agriculture is a farmer. He has a vested interest and indeed, what else would you expect him to say? So I should explain that the letter in front of you was paralleled by another sent to the Secretary of State for the Environment a few days later. The Society's view is that the issue must be taken out of the hands of MAFF and handled by the Secretary of State. Not only because he is higher ranking in the Cabinet but also because we would like to think that as the man with direct responsibility for the nation's wellbeing he will take a balanced view.

If you would be kind enough to read the Annex to our letter which reports on this year's burn, you will see that under various headings we have broken down the effects on individuals, their property and possessions. We had many letters reporting damage to fresh paint. Most of the fall-out came post-burn, sometimes days after the event, due to the high winds prevailing through much of the harvest. Complaints received over the telephone in just one afternoon ranged from Itchenor in Hampshire to London N21, whilst a lady in Ware enquired how to make immediate contact with the NFU as she wanted them to see how char was blowing into her house, under the door and around closed windows. Char even rained on Brighton for two days and elsewhere along the south coast. In the City of Cambridge it was reported that the visibility in the general area of the town was as low as three miles or less during a continuous period of 21 days. The sun changed colour and high levels of smoke in the atmosphere was present throughout the night.

You will also see a brief paragraph in the report concerning effects on health. Doctors have begun writing to the newspapers giving evidence of the effects on their own patients while we have had numerous letters from members of the public describing the effects of straw smoke on members of their families.

Effects on businesses and other industries are also listed. You will see that a large blanket factory in Oxfordshire had to close down while the workforce produced its own vacuum cleaners to clean newly manufactured stock. One Cambridgeshire firm lost all of its orders because its computer was out of action for four days because of smoke and smut damaging the mechanism. Another firm reported £14,000 worth of damage to freshly printed material. A market gardener reported the loss of 5,000 lettuces while a chrysanthemum grower said that he had to vacuum clean his flowers before sending them to market.

You will have read in the national press about the threats to road safety and some of the deplorable accidents that occured - and you will also know about the fire risks. Lincolnshire fire brigades were called out on 350 occasions and Cambridgeshire fought 261 stubble-related fires. Other counties were similarly affected.

Down the years this Society has always been known for its balance and objectivity, and with this in mind I would like to emphasise that we are not getting at the farmers - but at their practices. The farming industry provides 75% of the food which we eat; farmers and farm workers are 2½% of the national labour force and are in turn supported by another 8% of the workforce which produces everything from herbicides and fungicides to tractors and farm machinery and looks after its maintenance. So it is not surprising that farming comprises the biggest single industry in the country and the farmers are naturally proud of the fact. I would emphasise that we do understand the psychology of the farmer: he is a man who finds himself in a rat race with ever-increasing investments in plant and machinery to produce ever more grain from higher acreages and better yields. Thus he is under tremendous pressure. The minute he has finished one harvest he is under tremendous pressure to prepare the ground for the next. He is ill disposed to wait until the weather is exactly right to do what he has to do to prepare his land, and we understand his keeness to get on with the job. Given the vagaries of the English climate, given a fine day he will decide to burn - and then think about whether it was the right day to burn after it is over and done. Then he can get on with the next phase in the farming cycle. So the Society understands the farmers' problem and is sympathetic to their needs and always has been. The farmer says that he is part of an industry and we accept that he is. But at the same time, down the years, this Society has seen Government impose proper controls on all the other industries in these islands - and yet we do not have effective controls on this grave and ever increasing form of pollution.

I would like to remind you about the difference between straw burning and stubble burning. Straw burning occurs because farmers say they have no other way of economically disposing of surplus straw. To gather up straw takes power and machinery to bale it. It is bulky, expensive to move and however used its handling requires a lot of manpower. Farmers in the west of England will probably sell straw at £35 per ton for a variety of uses from animal bedding to (after treatment) animal feeding. Those in the centre of East Anglia, even where they can dispose of some of it, find that there is still a massive quantity left around for which there is no other economic means of disposal. MAFF calculates something between five and seven million tons of surplus straw is burnt annually.

Stubble burning is rather different, it is practiced on an increasing scale because the chaff left on the ground by the harvester after it has gone over the top decomposes only slowly. Pests live under it and fungi and other nasties grow on it. Where ploughing is abandoned in favour of minimal cultivation and direct drilling techniques to leave the chaff on the ground is to invite lower yields - and because yields are the name of the game the stubbles are burnt. Some organisations, indeed some political parties, think that stubble burning should be permitted on a different basis to straw burning. How then, does the Society view both issues.

As I said earlier, NSCA policy is really unchanged over the last three years - all we have done is to refine it: but we do say that the only way to prevent this pollution is to ban the practice. Obviously one can have all the codes and all the laws in the world, but whatever you burn and wherever you burn it the products of combustion will rise and the fall-out will come down - so if we are ever to be free of this blight, then it has to be banned. But, as I have said, what do you do with five or six or seven million tonnes of surplus straw annually when you are not geared to other methods of disposal? Well, the fact is that you cannot ban it overnight and the Society accepts this. We say, however, that there must be alternative ways of getting rid of it because, for example, the French on the plains of Picardy (where the soil is not dissimilar to that of the South Downs) have not really burnt any straw since 1975. When I spoke to the French Society in Paris they did not understand our problem and, indeed, the German Society does not really understand it either. So the problem is rather uniquely British although some burning takes place in Northern Germany and in Denmark. There are other means of disposal and further research will be necessary to develop them.

I started by saying that farming is an industry. If it is an industry, then under Section 1 of the Clean Air Act 1968 the practice of straw burning or stubble burning is already illegal. However, this has never been tested in the High Court and you will read therefore that the first requirement of our modified policy is for this to be done. But accepting that it is quite unrealistic to dispose of many millions of tons of surplus straw or to prevent stubble burning at a stroke, we propose, therefore, that a ban should be imposed after a short period to enable the research now underway into straw incorporation and feasibility studies into the transportation of straw, alternative uses and processing, to be completed and a strategy for the United Kingdom to be worked out and put into effect. As an essential spur to this end we consider that Parliament should legislate to introduce the ban within three to five years. In the meantime we consider that stringent legal controls are necessary to provide for the effective regulation of the practice by imposing on the farming industry the discipline which it is demonstrably incapable of imposing upon itself. In this respect, we note that Bye-laws are of no use where the nuisance is generated miles away, or days later, or where the source or sources of the pollution are not identifiable. And even where Bye-laws incorporate the NFU Code of Practice, their enforcement still presents major problems as in many circumstances action for non compliance is only possible after a field is well alight. Finally we say that whilst action under the Clean Air Act 1956 Section 16 may theoretically be possible, in practice it has been virtually impossible to implement and we are not aware that the law has ever been tested.

To overcome these problems, the Society proposes the introduction of powers similar in principle to those provided for the control of construction site noise under the Control of Pollution Act 1974. We believe that this would substantially strengthen the control which local authorities could impose on individual farms in their areas. In effect, farmers would be required to apply for a licence to burn, and the conditions under which burning may take place would be listed. Given such prior approval, local authorities could, amongst other things, prohibit burning after dusk, at weekends and during bank holidays; and prohibit burning when the forecast windspeeds for the local area exceed Force 3 for any part of the day (since law has to be simple one cannot make it for other than a single period of daylight); require cultivation within 24 hours of a burn to minimise subsequent lift of char or ash by the wind; and impose limitations on the area which may be burnt at any one time, either within an individual farm or within the district as a whole.

All of these proposed rules are to be found in the 1983 NFU Code in one form or another - so we are not really asking for anything terribly extravagant. What we are calling for is for the procedures commended to farmers by the National Farmers' Union to be given the teeth of law. Farmers would then know exactly where they stood. They would be in no different position, for example, to the man who drives a car with alcohol in his blood: breaking the law is then not a question of whether he is drunk or incapable of driving but whether the level of alcohol in his blood is above a certain figure. This makes for simple law which, facilitating prosecution, would add greatly to its deterrent effect. Our proposals are not perfect and will not solve the problem but they should ameliorate it and, pending an eventual ban, provide a practicable interim solution.

We are aware of a number of criticisms of these suggestions, the major one being that they would impose further strains on the resources of local authorities, which are already over stretched. To this we say "But we have simplified the law! If your resources cannot cope at the moment to the extent that we have simplified the burden of proof, this sort of legislation should make you that much better off!" We agree that setting the parameters for the first licence to be granted to a farmer would be a considerable task requiring special measures. However, the solution to this problem would necessarily have to be resolved by the Government in parallel with the drafting of the necessary legislation. Nevertheless, we believe our proposals to be essentially practicable. The Society has produced the basic idea - and on this it rests its case.

Text of the Letter from the Secretary General, NSCA, to
The Rt Hon Michael Jopling, MP
Minister for Agriculture, Fisheries and Food
Dated 14th October 1983

THE REGULATION OF STRAW AND STUBBLE BURNING

I am writing on behalf of the Council of the Society to reiterate our deep concern about the wholly uncontrolled pollution of vast areas of the country resulting from straw and stubble burning. As you have already announced your intention to enquire into the nature and extent of the complaints arising from this season's burn, I feel sure that there is no need for me to dwell further on the extreme resentment it has generated among whole sections of the nation - vastly outnumbering those farmers who profit by it. Evidence of the hazards to health and damage to property which follow in its train is attached.

In response to our letter to your predecessor in 1981, on the pollution arising from that year's harvest which, notably, was commensurate in scale with this season's, the then Minister of State, the Rt Hon The Earl Ferrers concluded inter alia "...I respect your concern, which I share, and I am not content with the position ... but I cannot agree that the situation has been reached where the balance has swung against continuing to permit straw to be burnt". Bearing in mind that:

1. there are no grounds for concluding that pollution episodes on the scale of those experienced in 1976, 1981 and 1983 will not be repeated next year or equally frequently in the future;
2. the acreage of cereals under cultivation continues to increase while oil seed rape residues and bean haulm are also being burned on an increasing scale;
3. in any event, and regardless of the dimensions of the problem nationally and the state of the weather, straw burning will continue to create substantial distress locally,

we should be grateful to know whether or not the views of your Ministry have in any way changed since 1981?

We would also like to commend to your attention our proposals for resolving the problem.

Firstly, it is self evident that the only way to prevent pollution from straw and stubble burning is to ban the practice. In this respect we note that should it be shown that farms are "industrial or trade premises" within the meaning of the Clean Air Act 1968 Section 1, then the practice is already unlawful. We consider, therefore, that the intentions of this legislation should, as a matter of urgency, be interpreted in the High Court. However, we consider it quite unrealistic to dispose of many millions of tonnes of surplus straw or to prohibit stubble burning at a stroke. We propose, therefore, that a ban should be imposed after a short period. This would enable research now underway into straw incorporation, and feasibility studies into the transportation of straw, alternative uses and processing to be completed, and a strategy for the UK to be worked out and put into effect. As an essential spur to this end we consider that Parliament should legislate to introduce the ban within, say, three to five years.

In the meantime, we consider that stringent legal controls are necessary to provide for the effective regulation of the practice by imposing on the farming industry the discipline which it is demonstrably incapable of imposing upon itself. In this respect we note that:

1. Bye-laws are of no use where the nuisance is generated miles away, or days later, or where the source or sources of the pollution are not identifiable;
2. where Bye-laws incorporate the NFU Code of Practice their enforcement still presents major problems as in many circumstances action for non-compliance is only possible after a field is well alight;

3. while action under the Clean Air Act 1956 Section 16 may be theoretically possible, in practice it is virtually impossible to implement and we are not aware that this law has ever been tested in the courts.

To overcome these problems the National Society has proposed - in its evidence to the Royal Commission on Environmental Pollution given in January 1982 - the introduction of powers similar in principle to those provided for the control of construction site noise (under the Control of Pollution Act 1974, Part 3 Sections 60 and 61) thus strengthening the control which local authorities could impose on individual farms in their areas. Given such prior approval powers, local authorities could, inter alia:

1. prohibit burning after dusk, at weekends and during bank holidays;
2. prohibit burning when meteorological office forecast windspeeds for the local area are in excess of Force 3 for any part of the day;
3. require cultivation within 24 hours of the burn, to minimise subsequent lift of char/ash by wind.
4. impose limitations on the area which may be burnt at any one time - either at an individual farm or within the district as a whole.

You will appreciate that in one form or another each of these measures features in the 1983 Revised Edition of the NFU Burning Code.

Such powers could be used to the full in areas where great tracts of land are burnt around rural villages or urban fringes. In some cases, and under certain weather conditions, the result might be to prohibit burning entirely for a period of time. This would be a penalty the farming industry would have to accept. While such regulation could not cure the problem we consider that it would significantly reduce it in the interim period until a ban can be implemented. Importantly, it would overcome the disadvantages inherent in the use of Bye-laws to control the practice and, equally importantly, it would eliminate the need to prove "nuisance". Prosecution of offenders would be vastly simplified, which would add greatly to the deterrent effect of the legislation.

We should be most pleased to receive your comments on the foregoing.

I am writing in similar terms to the Secretary of State for the Environment.

REPORT ON THE HARVEST BURN 1983

Areas affected

This year's Harvest Burn has brought complaints from twenty-four counties throughout the country: Essex, Lincolnshire, Suffolk, Hampshire, Cambridgeshire, Kent, Yorkshire, Oxfordshire, Middlesex, Cleveland, Hertfordshire, Somerset, Gloucestershire, Norfolk, Nottinghamshire, North Humberside, Northamptonshire and London N21!

Effects on Individuals

Some ninety individuals, many writing on behalf of their community, were moved to write to the NSCA over a 3 week period, following the publication of letters from the Society in The Daily Telegraph (1/9/83) and The Guardian (3/9/83). More representations were made over the phone. The vast majority of these complaints detailed the damage done to property by heavy falls of ash, smut and burnt straw. Paintwork both outside and inside homes has been dirtied - sometimes with apparently indelible black smudges - while soft furnishings and interior decoration have been damaged, again irreparably in some cases. Householders have expressed amazement at the ability of smuts to penetrate closed windows and at the long periods during which they have been subjected to this nuisance:

three to four weeks has been frequently quoted.

Smut and ash damage has been suffered some distance from the actual burn - Oxford City Centre experienced considerable fall-out - and on days when no burning took place. Some reports have been dramatic: a Cambridgeshire householder experienced bunches of flaming straw descending through an open window; a Wiltshire mother had difficulty in reassuring her children that the house was not on fire when their bedrooms were filled with black smoke; an Essex householder reported debris from straw and stubble burning several inches deep in his garden, with the consequent loss of home-grown vegetables and damage to plants and flowers.

Effects on health

The effects on health have been of major concern; we have received reports of hayfever type symptoms (eye irritation, catarrh, headache), chestpains and respiratory problems from people who are not normally sufferers. Children especially have complained of sore eyes and one mother describes particles of ash sticking stubbornly to the surface of her children's eyes. Such symptoms are confirmed by a Cambridgeshire GP who expresses concern about the health hazards of smoke from this source and a Hertfordshire doctor who is troubled by the possible damage to lungs from carcinogens present in the smoke. A Lincs GP reported chest complaints in patients who had not suffered previously.

Individuals or their relatives, and at least one doctor, have also reported aggravation of respiratory symptoms in persons suffering from bronchitis, asthma, emphysema and ischemic heart disease.

Effects on business, trade and community services

Industry, small businesses, schools, hospitals and communal activities have all suffered. In Lincolnshire, a power cut was caused by a field fire burning through a cable and the Eastern Electricity Board recounted several incidents of stubble ash being blown onto lines and tripping them out. A Linton firm (Cambs) suffered order delays of up to four days because its computers were unable to cope with the filthy atmosphere. A well-known Oxfordshire blanket company had to stop production because of smut fallout onto the newly produced stock.

The printing and double glazing industries have also had production affected by the soot-laden atmosphere. One Cambs printing firm lost £14,000 in spoiled work. Some market gardeners faced considerable losses or extra labour through damage to vegetables and flowers: one grower had to discard 5,000 lettuces which had been contaminated by smuts infiltrating his glasshouses through vital ventilation systems; a chrysanthemum grower had to clean smuts from individual blooms with a hair dryer. There have been reports of school text books and equipment being damaged; and one open air (school) swimming pool was unusable owing to the layer of dirt which had decended on it.

Hospitals in Essex, Cambridgeshire, Suffolk and Lincolnshire have been affected by the pollution. Papworth Hospital was subjected to an oily film on sterile instruments and containers; the same hospital had a false fire alarm when stubble fires burning close by set off the warning system. Work at the test-tube baby unit had to stop because of smoke penetrating the laboratories. The sheets of patients in intensive care at the West Suffolk Hospital were dirtied by smuts; Kettering General Hospital had to return sterile supplies for operating suites because they were covered in ash and soot.

Threats to road safety

Straw and stubble burning poses significant threats to safety when billowing clouds of smoke reduce visibility on roads and when fires get out of control. Motorists who have written to the Society with details of reduced visibility on roads have been alarmed by the experience of being suddenly enveloped in a thick blanket of smoke, unable to see either the vehicle ahead or oncoming traffic until it is right upon them.

In Cambridgeshire, visibility on many roads was poor, with the A1 and A1303 being particularly affected; other reports concerned the B1383, A11 and M11 in Essex, the A34 in Oxfordshire, the A10 in Hertfordshire, the Newport Pagnell by-pass in Buckinghamshire, the A435 in Gloucestershire and the A2 and A256 (Sandwich by-pass) in Kent. There were problems on the A45 near Bury St Edmunds, on many roads around Tunbridge Wells, on the Winchester to Arlesford road in Hampshire, the Halesworth road in Suffolk, and the Ramsgate to Garlinge road in Kent. On the Thanet Way in Kent, visibility was zero in some places. Just outside Stockton, Cleveland, there was an 8 vehicle pile-up when drivers were temporarily blinded by clouds of smoke across the road. In North Yorkshire on the A19 near Thirsk, a fatal road accident caused by smoke from straw burning resulted in two deaths. Three children suffered burns when 5 cars, 2 tankers, a truck and a caravan ploughed into each other. A straw fire had set light to a hedge; the smoke had drifted across the main road.

Fire Risks

Numerous fires have got out of control and fire brigades have had their resources stretched to the limit. In Kent, a lady came home to find her cottage garden in flames and a camp-site had a lucky escape when the surrounding hedge and fencing caught alight, but were quickly dealt with by firemen. People living in houses with thatched roofs have been frightened that their homes would catch fire, especially where there have been inadequate firebreaks. A Suffolk householder expressed amazement at the size and heat of the fires around him, with only one man in charge and, on occasions, only the farmer's children. Reports of flames 40 or 50 feet high are not uncommon. A motorist in Wiltshire was able to feel the intense heat from stubble fires through the closed windows of his car when driving along a lane, and countless hedgerows have been destroyed.

Cost

Quite apart from the danger to life and property, the expense caused by straw and stubble burning has been enormous. In Cambridgeshire alone, the season's bill for stubble fire-fighting exceeds £30,000. (Cambridgeshire Fire and Rescue Service fought 261 stubble related fires between July 1st and September 1st.)

Lincolnshire Fire Brigade attended more than 350 harvest fires in July and August, some individual fires having cost as much as £4,000 to bring under control. In Tolleshunt Knights, Essex, one fire was fought for nearly 2 hours by 5 fire brigades.

The overall cost, however, is impossible to estimate, either in terms of money or time and effort. Most Local Authority Environmental Health Committees meet during September and October, so it is too early yet to receive their reports; nevertheless several LAs have already contacted the Society as a result of complaints about the enormous cost and nuisance suffered by public services, industry and individuals from the effects of the harvest burn.

Local Authority Reactions

Charnwood BC (Leicestershire) received a considerable number of complaints relating specifically to: the choking, acrid smell; sooty ash falling out on houses; the destruction of hedgerows and wildlife; and the dangerous reduction of visibility on highways. Mr Rook, the Borough Environmental Health Officer, has called for further restrictions on the practice of straw and stubble burning. Oxford County Council Environmental Health and Control Committee have unanimously agreed that it is necessary to ban the practice - a course of action also favoured by Cleethorpes Borough Council. Uttlesford District Council (Essex) report that they have received 163 complaints in all, while South Cambridgeshire District Council are planning to prosecute a farmer for nuisance owing to the pollution of an entire village by smuts and soot from straw and stubble burning. South Holland District Council (Lincs) has voted to make the practice illegal under the bye-laws, with heavy fines for offenders; and in Norfolk, all district councils have adopted bye-laws on straw and stubble burning. Contraventions are pursued by Fire Officers when the fire service is called out to a harvest fire.

In the Cambridge area, an all-party group has agreed to press the Home Secretary and Parliament for legislation banning straw and stubble burning.

Other local authority CEHOs have contacted the Society to express their concern about the practice and its effects, and raise specific points, before presenting reports on the subject to their respective Environmental Health Committees. The outcome of deliberations within these local authorities is awaited with interest. It is anticipated that most will make representations to the ADC, NSCA and other national bodies, advocating a ban or stringent legal controls.

Many of those individuals who have written to the Society have also alerted their MPs to the problem; and several MPs are actively seeking to secure a ban on the practice.

East Anglia appears to have been the area worst affected, with Cambridgeshire, Norfolk and Suffolk suffering badly. According to figures from MAFF, there has been a 50% increase in the amount of wheat grown in East Anglia over the period 1975-1980 and 2.5 times the area of land has been given over to oil seed rape.

The extent of the area burned in East Anglia and elsewhere, together with the weather conditions, created widespread pollution. The heat of the fires was itself sufficiently intense to create strong thermal rise which, in conjunction with the weather conditions - anti-cyclonic, hot in August, windy in September - caused smoke, char and smuts to be carried relatively high into the atmosphere and remain airborne long enough to travel considerable distances. Parts of Humberside have been badly affected by burns in Lincolnshire, to the south. While weather conditions vary from year to year and 1983 conditions may not be replicated exactly in future years, it should be remembered that there were also considerable problems in 1981, only 2 years previously. Notably, the trend in the amount of surplus straw and the area of land burned is ever upward.

28 September 1983

STRAW AND STUBBLE BURNING - THE VIEW OF THE COUNTRYSIDE COMMISSION

Mr. Keith Turner, Land Management Adviser,
Countryside Commission

My purpose is to put over the Countryside Commission's viewpoint about straw and stubble burning. The Countryside Commission has a wide remit: in fact, some people have been tempted to say that it is so wide we can mind anybody's business and would generally end up by doing so! However, the Commission has a statutory duty, under the 1968 Countryside Act, to protect and promote conservation, informal recreation, and access to the countryside. We are the Government's main advisers on those aspects, and in some ways we are regarded as a countryside watchdog. I now intend to go over again some of the points which the NSCA's Secretary General has just mentioned: bear with me on that, since I feel I ought to put over clearly the reasoning behind the Countryside Commission's decision this autumn to call for a ban on straw burning.

I shall look first at the agricultural case for burning, a case which we readily admit is extremely strong. Historically, there has been a freedom of action by farmers to deal with their crop residues in which ever way they choose. However, there has been an enormous expansion in cereal growing since the 2nd World War and I believe that now there is something like double the acreage of cereals grown in Britain. There has also been the introduction of what could be called "high tech" production methods for cereals: the growth of a crop of wheat, barley or oats has changed out of all recognition. Behind it all is an engine of economic power, fuelled by the Common Agricultural Policy.

The result has been to force on farmers the need for the rapid establishment of a sequence of two or three mainly winter cereal crops, replacing the old fashioned rotations under which, previously, there would have been perhaps half a dozen or more different crops.

Winter cereals, and winter wheat in particular, need to be sown early in order to achieve its maximum yield. In turn, that puts immediate pressure on farmers to deal with the previous crop. The problems arising out of stubble and straw burning are a result of this desire to get the previous crop out of the way as quickly as possible and to clean the ground by burning, in order to put in the next crop of wheat or barley. In many instances, certainly in the last five or seven years, the problem has been exacerbated by the introduction of yet another new crop: oil seel rape. Its demands for early sowing are even more stringent than those of winter wheat. Thus, as far as farmers are concerned, they have a very good case indeed for burning their surplus straw residues and getting them out of the way.

The problem, of course, is that this has in turn created lots of difficulties for other people. 25 years ago, there was a relatively small cereal acreage compared to today, with relatively little straw burnt and relatively few problems - I hope that is not too much of an over-simplification. Now, with the widespread cereal based rotations in most of southern and eastern England, with record acreages of cereals producing record yields (it is interesting to note that the yield of cereals in Britain in 1982, and certainly for winter wheat in 1983, is another record) in turn producing this massive surplus of straw.

We have just heard a catalogue of the problems arising out of straw burning. I must say that there are also problems for the farmers; indeed, I think farmers would be the first to admit that if there was a more economic and practical way of dealing with it rather than burning, many farmers would use the alternative. At present, however, baling and carting the straw away from the farm presents substantial economic problems: it is expensive to do, and it is time consuming. In view of the need to clear the previous crop and get another one in, the introduction of some physical way of removing the straw from the farm imposes difficulties, particularly during a "catchy" season weatherwise. But there are of course problems for everybody else.

The Countryside Commission is most concerned with problems in the landscape. One of our main areas of responsibility is the promotion of a landscape of interest and diversity, a landscape full of beauty and character and in particular a landscape where people can enjoy what is traditionally regarded as an attractive countryside. Bearing in mind that Britain has a landscape which is universally recognised as being amongst the most beautiful in the world, we are the first to recognise that it is the hand of farming over the years that has created that landscape. It has been the successive and generally slow changes in agriculture and agricultural progress which has led to the kind of beauty that poets, painters and others extoll. Unfortunately, since the last War (or possibly a bit before) the economic and technical advances in agriculture have moved to the point where farming is now potentially the greatest threat to the landscape. Even with the advent of the Town and Country Planning Act, agriculture was not regarded as in any way a threat to the countryside; it was, rather, regarded as perhaps the most benign influence on it. Now, however, there is such a radically changed situation that it is now very often perceived to be a major threat to the landscape. Straw burning is just one aspect of that threat and the damage that irresponsible and badly implemented straw burning does to the landscape is what the Commission is most concerned about.

Burning now often begins in mid July and it can go on until mid September, with a peak in August. As far as the farmer is concerned, a "good burn" provides the ideal situation in which to establish either a crop of oil seed rape or a crop of cereals. It destroys the residues, leaving the ground clear and largely free of weeds and pests. That is what the farmer wishes to see: and indeed, if the job is done properly and the Code followed properly, then as far as the landscape is concerned there should not have been the kind of damage which occurred this year. Straw burning, if carried out in strict adherence to the Code with the burn against the wind and fire breaks properly made, should have left hedgerows and hedgerow trees largely untouched.

Unfortunately, since the Code was introduced, all too often there has been severe damage to hedgerows and hedgerow features (which are, in any case, in many instances a problem to farmers since they often divide into fields areas which they would be much happier cultivating as one). The damage is not confined to hedgerows but also to trees: trees 40 or 50 ft high have been very severely scorched, in spite of there being a reasonably adequate fire break, because the straw was set alight in very high winds. Such damage was repeated in many parts of the country. Slight scorching is probably of no lasting harm to many trees and hedgerows; but we now have evidence from many parts of the country that, where there is severe scorching and damage, many trees and hedgerow shrubs are progressively killed out and replaced by aggressive weed species, biologically far less valuable. The landscape is severely disfigured, and if this is allowed to continue to happen, then it will be yet another factor to add to the causes of the erosion of landscape features which give so much character and diversity to the countryside. In some areas, even private gardens have been invaded by the problems of straw burning.

We feel very strongly that that kind of damage should not have occurred had the Code been followed properly. When one examines the Code, then there are, I would suggest, provisions in it to cope with virtually all the kinds of conditions which occur during the summer months. The summary on the front of the Code suggests making an effective firebreak of at least

15 metres wide. So far as the Commission is concerned, we feel that is insufficient and we said so during discussions at the drafting stage. We went along with it because there were other recommendations to make wider firebreaks in other conditions.

The Code also says "Never burn when wind conditions are unsuitable", and this is explained in more detail later. Other advice, summarised, is: "Burn against the wind whenever possible. Ensure that burning is responsibly supervised. Burn only during daylight. Inform your neighbours. Notify the local fire brigade if required by local bye-laws. Take extra precautions where there is a risk of causing damage or annoyance to the public. Avoid burning on a bank holiday and during the week ends whenever possible". Inside, the leaflet explaining the Code goes into some detail about how the provisions can be implemented. I would draw your attention to two aspects of the Code which should have been particularly relevant in the past season. First: "Burn against the wind whenever possible"; but it also states that, where it is necessary to burn with the wind, farmers should first remove or burn at least 30 metres of straw in addition to the firebreak, at the downwind end of the area to be burnt. In other words, where there is a strong wind blowing, or a wind which will cause the fire to advance more rapidly than it would in still conditions, then there is an obligation to make much wider fire breaks. That obligation was, very clearly, very substantially broken throughout this last summer.

The second aspect of the Code, even more pertinent, was the injunction to avoid burning during prolonged hot and dry weather. In many districts in southern and eastern England, the rain stopped at the end of May and did not start again until the middle of September. It was a very long and prolonged dry period and although there could have been local thunderstorms which might have affected the local situation, generally speaking August was a period of prolonged hot dry weather. The Code says: "Should it be necessary to burn after more than two weeks of hot weather without rain, extra precautions must be taken to avoid damage and the dispersal of smuts over a wide area. For example, burn early in the morning when there is a dew and make wider firebreaks than normal."

We felt that the 1982 revised version of the Code was fairly watertight in terms of prevention of damage to the landscape. However, this view changes on looking at the record of the Code. It was introduced in 1972, and since then we have had ten or eleven years of it in operation. During at least five of those years, quite substantial problems have occurred, not only from the landscape point of view but indeed in terms of nuisance and hazard because of pollution. Particularly bad years were 1975, 1976, 1979 and 1981. There was a major outcry after the 1981 harvest which led to a revised and strengthened Code for 1982, and of course this year. All the bad years were characterised by generally fine and dry Augusts. Although the Commission supported the Code, and helped to draw up the tighter provisions, we made it clear to the National Farmers' Union that unless the Code was seen to be effective, then the Commission would reserve the right to change its mind about supporting it.

Reviewing the situation in 1983, clearly there has been very widespread damage, the heaviest and probably most widespread on record. Indeed, it has also been very noticeable that the complaints about straw burning as a public nuisance factor, as opposed to the damage which has occurred to landscape, has been of a totally different order. It is significant that the "problem" has got as far as the towns; certainly, on the evidence of this past season, strawburning is no longer simply a rural problem. Town and villages have been affected in quite a big way, and the voice of protest about this practice has reached new heights. It is also interesting to note that there has been widespread protest from within farming circles, particularly from some members of the horticultural industry. We would submit that 1983 was the year when the Code failed at a time when it was most needed!

The Countryside Commission met on October 6th to consider the matter. Bearing in mind its responsibility for the protection of the countryside and its need to act as a watchdog, the Commission considered the whole problem very carefully indeed. The following day the Commission issued a press notice, and I propose now to read just one section of it so that it is quite clear what the position is: "At its meeting on Thursday October 6th, the Commission decided to recommend to Government that burning should be phased out over a period of three years. While recognising that in the forseable future the bulk of straw would have to stay on the farms where it is produced, the Commission urges there should be an early concentration of research into the problems of the physical incorporation of straw with a wide variety of soil types. Although all the problems may not be overcome in three years, the Commission hopes that acknowledgement by Government of the need for an eventual ban will concentrate and expand research in all the necessary fields." This statement was made against the background of a large degree of disappointment and regret that the Code which the Commission had supported was, on its own record, no longer effective. We were indeed very sorry to have to make that statement and we do have considerable sympathy for the many farmers who do take enormous care and trouble to avoid damage and nuisance to anybody else. However, we believe now that this problem is not one that can be adequately controlled by voluntary methods.

We have looked at the possibility of licensing, but we feel that that is essentially impracticable. There are all kinds of problems with licensing as a means of controlling farmers' activities: although we may well concede that if it is proved by research that, in certain soil types, the physical incorporation of straw is not possible, then clearly that position may have to be reviewed. But, in general, we do not feel that licensing is a practicable way of dealing with the problem. The advice which we have received on bye-laws also suggests that they are, by and large, unenforceable on this issue. The law which governs the problem of burning in the countryside is one covered by a number of acts. Advice from the Association of District Council is that they are very reluctant to pursue any prosecutions because of the difficulties of securing one that will succeed. We understand that the tightening up of bye-laws poses all kinds of problems; nevertheless, this is being looked at again, and it will be interesting to see whether the Government comes up with some solutions.

But, as far as the Commission was concerned, its policy decision was taken in the light not only of its interest in the future of the countryside, but also in view of the fact there was already a high level of research into the problems of incorporating straw into the soil, which is perhaps the most "ecologically correct" method of dealing with it.

The Chairman of the Commission has written to the Minister of Agriculture, Fisheries and Food, to the Secretary of State for the Environment, and indeed to Home Office. A reply has been received from Mr. Jopling, one paragraph of which runs:"I cannot, however, endorse the idea of a complete prohibition of straw burning by farmers, certainly until satisfactory alternative methods of straw disposal are available." (a slight door is left open there) "In their absence, burning represents the only practicable solution to the problem presented by the five or six million tonnes of surplus straw".

So our main effort now is to try and encourage the research into dealing with this problem to continue apace. Efforts must be redoubled, because we feel that in the end a ban will certainly occur. It is interesting to note that a number of other countryside organisations, for example the Nature Conservancy Council, the Royal Society for Nature Conservation and other organisations like Friends of the Earth support a ban, as does your own Society. We await with interest the views of the Association of District Councils and the Association of County Councils. We feel that there is now a broad base of support for, eventually, a complete ban on straw burning which will remove this problem from the countryside.

DISCUSSION

MR W F HERON (Brighton BC) opening the discussion, said that passionate speeches were rare but welcome at NSCA conferences. Two such excellent speeches were, however, a hard act to follow. Coming from Brighton, Mr Heron was only five minutes' walk away from the NSCA Headquarters; he had taken the trouble to go through the Society's press file on straw and stubble burning and had been astonished by the number of reports collected in just one summer. He found it incredible that, in 1983, an industry could take the risks that it did.

One report had been of a lady who had had flames within three metres of her back door. With so much Health and Safety at Work legislation around, such an occurrence was startling. On another occasion, a central sterilising and supply department had been completely closed because of char that had got into the works, endangering operations. Mr Heron had found some of the comments from individuals quite amusing. One man had suggested the problem could be overcome by growing straw shorter! Another had suggested the 1983 summer would have been an excellent time to make a war film, since footage of clouds of smoke and burning fields would suggest the scene at Dunkirk. In his own back garden in Hove, Mr Heron had watched the sun change colour as a great cloud of smoke had drifted across its face.

In Brighton, fortunately, the Environmental Health Committee had accepted a report put forward by the Borough Environmental Health Officer, which had been supported by the Society's Secretary General. The report had been stimulated by the large number of complaints received during 1983 from residents in the Brighton area. Before then, Mr Heron admitted that he had not considered straw and stubble burning to be a problem in Brighton; he had not contacted the Society, volunteering to take part in the survey, since he had not thought there would be anything to survey. Yet, in 1983 the area had been inundated with smoke, char and complaints. Both speakers had pointed out how inadequate the NFU code was. Mr Heron said that one of the resolutions from his Environmental Health Committee had been to write to local MPs seeking support for NSCA policy and action. Andrew Bowden, who was always willing to listen to the Environmental Health Department, had written to the Minister at the Department of Agriculture, Fisheries and Food and a reply had been received from Lord Belstead. From this, it had emerged that the official line was that there was no adequate alternative to burning as a means of straw disposal, that increased cereal production was a jolly good thing; in fact, Mr Heron had been left with the impression that the letter had been drafted by civil servants straight out of the TV programme "Yes, Minister". The attitude displayed was "We will implement an inquiry and hope that the problem will go away".

In conclusion, Mr Heron said that his council had given full support to the NSCA stand on straw and stubble burning, and had written to the ADC, pressing home the case. He hoped that councils represented by other delegates at the conference would be able to do the same.

MR DAVID COLLIER (National Farmers' Union) thanked the NSCA for the opportunity to speak on this topic at the conference. Turning first to Mr Turner's remarks, he said that the NFU could disagree with very little he had said; equally, they would disagree with little in Air Commodore John Langston's remarks. The major point of disagreement was on the proposal for a ban on straw and stubble burning. As had already been pointed out, there was a considerable surplus of straw, in the region of 6 million tonnes, and there were at present no practicable alternatives to disposal by burning.

He wished to highlight the consequences of imposing a ban before alternatives were properly worked out. The first was the hazard (of straw being set alight unplanned), which would be greatest in the years in which straw burning itself caused the most problems. He drew a picture of millions of tonnes of straw lying in the field to be set alight - possibly by vandals, but more probably by accident. The NFU had received reports from Fire services which suggested that many fires had been started by accident or more deliberate causes. On this ground alone, the NFU considered a ban to be dangerous. Mr Tory would talk later about research (into alternative uses of straw) being conducted at the moment, and the prospect of finding proper alternatives within a reasonable period of time.

Turning to a few of the other points made, Mr Collier referred first to the possibility of a code of practice being introduced, similar to that which controlled noise from construction sites under the Control of Pollution Act. His first point about this proposal was that it would put a strain on the manpower resources of local councils' Environmental Health Departments, right across the eastern side of the country. Not only would the environmental health officer have to take a phone call from a farmer, to find out where he was going to burn (if he could burn at all), but he would also need to impose conditions and he would have to take account of variations in weather, etc., across a wide area. It would presumably be necessary to delegate powers to these officers, and there would also be a need for a right of appeal against decisions, and various other administrative problems. Finally, the scope of the code would be restricted, in the main if not entirely, to problems of pollution. There would be no possibility of covering damage, or danger to the public.

The NFU was itself making proposals to Government to control burning, the first point being that there was a very clear need to tighten controls. The firebreaks were inadequate. A 3-metre ploughed strip was not enough, and there was no duty to provide a firebreak where a field was adjacent to a road and separated from it only by a fence. The NFU was proposing that there should be two supervisors in charge of the burn, not just the one, as at present. Further, that one of these should have had previous experience in burning. The NFU was therefore encouraging people to take up the courses already offered by the Agricultural Training Board. Thirdly, the NFU was proposing that there should be a ban on burning at weekends and on bank holidays, when the public were likely to be in the countryside in the larges largest numbers. Fourthly, the NFU was proposing that there should be a limit on area burnt of 6 hectares, and that ash should be incorporated within hours of burning. (The NFU stipulated 36 hours, and the NSCA sought incorporation after 24 hours, but Mr Collier did not think that there was any great deal of difference there). The NFU was also seeking to tighten up on deterrent measures. There was already a maximum fine of £1000, a higher amount than formerly, which had been pushed through by the NFU. However, the Union now felt that that was not in itself enough.

In conclusion, Mr Collier said that NFU discussions on straw and stubble burning were well underway; the Union was open to any suggestions from the NSCA conference or individual delegates; specifically, on any ways in which the bye-laws or any other controls could be used or improved upon.

MR P J W TORY (National Farmers' Union) said that he was both a farmer and a straw burner. He farmed right round an urban area and in four years he had never had any complaints of smut or char because he had made an effort to find out how to burn efficiently. Apparently, MAFF had carried out such work ten years previously, but had since forgotten about it. His own research had been undertaken with the help of a friend in an aeroplane at a height of about 1000 feet. They had examined the effects of different types of burn, by sectioning the field into strips with a) straw straight out of the back of a combine, b) straw spread out from the back of a combine and, c) straw chopped and spread from the back of a combine. With the first plot, the aeroplane pilot had found smuts at 1000 ft, rising with the heat; with the second plot conditions had been not quite as bad but still not good enough; but with the third plot, following the chopped and spread straw method he had used for the past four years, there had been virtually white smoke, a low level of flame, no uplift of smut while burning, and the remaining ash and stubble had been absolutely negligible - so much so, that when the following day a television crew had come down to use the field for a film on straw and stubble burning, it could not do so because it did not look as if it had been burnt. Mr Tory said that he was a member of Lord Belstead's straw utilisation committee, which met several times a year, and he had submitted his findings on straw burning in a paper to the Committee, which had received it with a good deal of enthusiasm.

Moving on to the subject of incorporation, Mr Tory said that there were six research stations which, for the last three years or more, had been doing work on incorporation of straw (in soil). In addition, research was also being carried out at the Agricultural Research Centre's laboratories at Letcombe. The problem at the moment lay in the reduction in yield, of between 16 and 29 per cent, when straw was incorporated, whether it was by ploughing, by tines, or by discs. One possible solution to the problem was offered by the work at Letcombe into microbiological degradation of straw, so far within a compost system. However, the NFU had asked Letcombe whether it would be possible to spray the degrading compound out over the straw from the back of the combine, so that an initial rot would be produced immediately in the straw.

The main problem with incorporating straw into soil was the large amount of acetic acid produced as it rotted. Thus, there had to be a ten week period to allow for rotting, before a farmer could contemplate sowing the next crop - and yield was still reduced. Ten weeks took the farmer virtually into December, which was far too late to start sowing winter crops. However, an enormous amount of money was being spent, both by 24 firms represented on Lord Belstead's working committee, and by the Government itself, into alternative uses for straw. More money would be needed if those efforts were to be successful. One possibility was that farmers themselves might put up some money for research and development into alternative uses for straw.

To talk of introducing a ban in three years' time was, Mr Tory said, fine in principle, in that it would push things along; however at the end of that period Britain would still be faced with the same problem that Germany had now. The Germans were still on a low yield plateau and farmers were still bringing up unrotted straw so that fields had to be ploughed up to four times over. That consumed a great deal of energy, and incidentally created pollution - from tractor exhaust. According to the French Government, French farmers still burnt straw, anything up to 5 million tonnes per annum. But the French equivalent of local councils told farmers when they could burn. If conditions were unfavourable the Mayor would tell farmers "you cannot burn".

One of the major difficulties, as he saw it, in the UK was that although bye-laws existed, no one was prepared to follow them up, even when the requirements about firebreaks were flagrantly breached. Taking up Air Cdre Langston's parallel with drink and driving, Mr Tory said that were he to be drunk in charge of a vehicle, he would be fined after, not before, he got drunk. If it was obvious, after the burn, that a farmer had not conformed to bye-law requirements, then again farmers should be prosecuted and fined £1000 and would soon learn to observe the Code.

MR CARSON (Newport BC) felt that the problem was wider than straw and stubble burning, odours from the spreading of slurry, or insufficient control on development of agricultural land: the pollution control laws were adequate, but were not being applied to the agricultural industry as distinct from any other industry. Little grey haired ladies were prosecuted under Section 16 of the 1956 Clean Air Act, for causing a nuisance through burning a bonfire, but nothing was done when whole counties were blackened by smoke from straw and stubble burning during the harvest season. Action would be taken against a trader or industrialist under the 1968 Clean Air Act Section I for prohibition of dark smoke created by the farming community. Action would be taken against a neighbour causing a nuisance for some reason, whether it was odour caused by bad drains or cooking, but the environmental health department did nothing and could do nothing about the spreading of sludge on land. Action was taken against a person who violated the Town and Country Planning Acts by erecting a wall higher than two metres, without planning permission, but the farming community was allowed to develop on several thousand feet without planning permission.

Mr Carson said that he did not require any additional laws, all he needed was that the farming community should be required to comply with the same laws that everyone else was subject to. On that basis, problems such as had been detailed would never arise. Modern agricultural methods, with intensive livestock rearing and high production processes, put agriculture on the same footing as highly commercial and industrialised enterprises and therefore under even greater obligation to comply with the same laws as the rest of society. New laws would not be necessary if the farming community was forced to comply with existing ones.

MR LARKINSON (South Holland DC) said that he had listened with great interest to the comments made by the Society's Secretary General, Mr Turner and the representatives from the NFU. In his own area of South Lincolnshire, there were quite a lot of farmers, many of whom were not members of the NFU. The Code of Practice was, in his opinion, totally ineffective. The farmers response was to call for greater enforcement by the local authorities, but he pointed out that July, August and September were, for local authorities as for many other people, the holiday months and EHOs were thin on the ground in rural areas at that time. Ash Wednesday had recurred on the 2nd September, "Black Friday" in Lincolnshire. In markets, fish and meat stores had to pack up their wares and go home at 11 o'clock in the morning and people had had to switch on their car headlights in order to drive in the fens.

Mr Larkinson wished to propose to the conference that it should send a resolution to the Prime Minister to introduce a ban on straw and stubble burning, not in 3 or 5 years' time, but immediately. His own council was thoroughly behind this proposal (and it should be remembered that winter corn was already two inches high).

AIR COMMODORE LANGSTON, replying to earlier points, said that farmers came in all shapes and sizes. Some were highly responsible and learned members of the community, who farmed in accordance with the best possible practices. Others were not members of the National Farmers Union; others were totally inconsiderate of their fellows; some simply lacking in common sense. Licensing had been called an impractical solution. However, Air Cdre Langston pointed out that the Society was not seeking to introduce a complicated procedure, but was merely saying that a farmer who wanted to burn should apply to the Local Authority and (with the decision, of course, subject to appeal) could be told for example: "You may burn, sir, but not on a weekend or after dark", which would be a very simple law which the farmer would understand, and which would in itself be a deterrent.

MR W B TWYFORD (NSCA Immediate Past Chairman) said that in his presentation of the Chairman's Report to the AGM on the afternoon of Monday 31 October, he had touched briefly on the subject of straw and stubble burning, making one categoric statement: that the conditions prevailing in 1983 should never be allowed to recur. That had been accepted by the AGM. He had also queried whether the Minister of Agriculture, Fisheries and Food was the right person to have control of the practice of

straw and stubble burning in view of the pollution problems arising from it. He had then expressed the hope that the conference would pass a resolution to Government in support of the policy set out in the letter sent by the Secretary General on behalf of the Society's council. Mr Twyford thought that such a resolution, coming from the conference which represented the Society as a whole, would be most useful. He then proposed the resolution in the following words:
"That this conference endorses in full the views set out in the letter sent by the Secretary General to the Minister for Agriculture, Fisheries and Food on the 14th October 1983, and the subsequent letter to the Secretary of State for the Environment, and urges Her Majesty's Government to take urgent action to bring about the recommendations contained therein. It is also resolved that a copy of this resolution be sent to each of the local authority associations, seeking their support in this matter."

Mr Twyford expressed the hope that conference would feel able to support this resolution, for transmission to Government and to the local authority associations. In his view, it represented a practical approach. Whilst he had considerable sympathy with the emotions expressed by Mr Larkinson, Mr Twyford felt that the farmers' immediate problem of straw disposal could not be ignored, and that therefore burning could not be banned overnight. There had to be an interim period for the necessary research. He therefore felt that the Society's policy was the correct one, and formally moved his resolution.

Conference approval for the resolution was overwhelming.

SESSION FIVE
NOISE - CURRENT ISSUES

INSULATION OF BUILDINGS AGAINST EXTERNAL NOISE
Dr W A Utley, Building Research Establishment, Watford

TRANSPORTATION NOISE CONTROL THROUGH PLANNING
G Vulkan, Scientific Services Branch, Greater London Council

REVIEW OF NOISE INDICES AND FUTURE REQUIREMENTS
P Sutton, Acoustic Technology Ltd, Southampton

CLLR MRS B J SOLKHON (Brighton Borough Council) asked Dr Utley about the possibility of preventing noise in newly-converted buildings. The area she represented, Brighton, had many large old buildings which were constantly being converted for multiple occupation. In such cases as warden homes, where the occupants were roughly the same age and disinclined to indulge in very noisy activities, multiple occupation did not create noise problems. However, where there was a diversity of population in one building, there might be a family with children crying in one flat, a student in another room needing quiet for study, and an elderly person (perhaps the original owner of the house who, through force of circumstances, had been obliged to convert the building). Such situations could create great difficulties because of noise transmission through party walls and floor.

Mrs. Solkhon said that she herself was experiencing difficulty during her stay in Torquay. She found herself taking two baths a day in her hotel room - one for herself and one shared with the gentleman in the next bedroom! That was a good example of a building which had been converted, and had bathrooms added, but without attention to the noise factor. Therefore, she asked Dr. Utley what advice, and what hope, he could offer for reasonable cost-conscious insulation which would encourage landlords (not a philanthropic breed, by and large) to give reasonable living conditions.

On a personal note, Mrs Solkhon said that she looked forward to welcoming delegates to the NSCA Conference in Brighton, October 1st - 4th 1984. She hoped that, were she still to be Chairman of the Environmental Health Committee, she would have the opportunity of seeing them there.

DR W A UTLEY, answering the question about noise insulation in buildings converted for multiple occupation, said that some six or seven years earlier, the Building Research Association had published the results of some research on improving the insulation of existing wood joist floors (typically found inside semi-detached homes) to cover the situation where such houses were converted into flats. The results had shown that it was possible to carry out modifications to bring the performance of the floors very close to that which would be expected in purpose-built flats. So that, on the technical side, adequate insulation was possible. On the control side, there was the question of whether the Building Regulations would stipulate such improvements in the future. That was another matter, but it was certainly technically possible in many cases to improve the floor insulation, which was where the problems largely lay in converted houses.

It was unusual to find a building so large that there would be two dwellings on the same floor, therefore transmission through party walls was less of a problem in converted buildings. Even with party walls, however, it should be possible to do something to improve the insulation quality.

MR G VULKAN said that it was much more difficult to upgrade noise insulation in existing, older buildings. They were currently experiencing problems in London, where an attempt was being made to rehabilitate older buildings and convert them into flats; as a result, living rooms were now often situated above bedrooms. Because of the extent of the problem, the GLC Scientific Branch had carried out a project and one of Mr Vulkan's colleagues had recently published a paper on sound insulation in that type of situation. Mr. Vulkan said he would be pleased to send a copy of the paper, by Mr Stephen Turner, to Mrs Solkhon.

MR G R CHARNLEY (Southampton City Council) congratulated all three speakers on very interesting presentations. He particularly commended Mr Vulkan for recognising that dB(A) was not the universal cure in all situations, particularly with low frequency noise. He also congratulated Mr Peter Sutton for removing the brackets from dB(A) in his paper!

On pages 10 and 11 of Mr Sutton's paper, he had made reference to L percentiles; Mr Charnley said that for some time he had been concerned about the use of L percentiles. Peter Sutton had referred to the superimposition of noise from, say, a factory on to an existing background. Mr Charnley illustrated such a situation (see Fig. 1) by superimposing a sound at 42/3 dB (L_{50} = 42.5dB) on a background distribution, the L_{90} of which was 42.5dB. The main thrust of Mr Charnley's comment and figure was to draw attention to one of the better features of Circular 10/73: avoid the creeping increase in ambient noise levels. He did not think that Mr Sutton's assertions were necessarily true. Referring to his overhead figure, he said that, comparing the new predicted distribution with the background distribution, it could be seen that the L_{90} had increased from 42.5 to 45.6, an increase of 3 dB. The Leq had increased from 45.4 to 47.2, a 2 dB increase. He felt that it really paid to do the mathematical juggling with the L percentiles; although it was a tedious exercise adding one distribution to another logarithmically, it was a worthwhile exercise in the process of long-term planning design for the environment.

Turning to the subject of internal noise insulation, Mr Charnley referred to an architect who had been given an internal noise criterion to meet in the design of a new dwelling. He had achieved it by including in the design the installation of heavy, fixed single glazing, with a mechanical ventilator unit to cover the ventilation requirements. That case illustrated the ease with which design specialists became blinkered and ignored the real needs of people who would live in the rooms thereafter. For example, such design ignored the fire safety aspect - old people or children especially would find it difficult to break through heavy single glazing in case of fire. It also ignored the human need for openable windows, even if only for aesthetic reasons. Designers were fond of effectively isolating people in little boxes in order to meet rigid cost limits. L_{10} took account of traffic noise but there was usually a quiet period in the middle of the day when people might like to open the window in their living room. He asked whether Dr Utley had come across any other aspects that had to be considered in designing to meet internal noise specifications. He also asked whether the improvement in insulation against external traffic noise had increased the occupants' consciousness of noise from their neighbours.

Lastly, Mr Charnley made a plea for a more practical approach to noise control. Practitioners used their ears, sound level meters, their fingers (to detect vibration); perhaps the use of their eyes might be better exploited. In Germany, for example, a curfew system was used for the control of noise from light aircraft and pleasure flights were not permitted on Sundays. In relation to warehouse premises, everyone knew that associated vehicle movements, loading and unloading would create problems at night; he suggested, therefore, that it might be more practical to employ curfew controls than to set unrealistic noise limits.

MR P SUTTON said that Mr Charnley's remarks highlighted the difficulty of using different indices for different things, eg. L_{90} for background, L_{50} for factory noise. They could not be added or subtracted as if they were based on the same index.

On the basis of his calculation, Geoff Charnley had found that the L_{90} ambient had been increased by 3 dB, and the L_{eq} had been increased by 2 dB - that indicated that if one used a different index, one got a different figure for increase in noise level. Following the Noise Measurement and Registers Regulations for distant factories, and measuring downwind, that downwind measurement only applied on certain days of the year - which meant that one was dealing with quite a different index all over again. Thus, he felt that Geoff Charnley had highlighted a very important point in the use of indices: that, when using more than one, it was important to know exactly what one was using when adding and subtracting noise levels. Life would perhaps be a lot simpler if a CNL L_{eq} with the same time-blocks were used.

He thoroughly agreed with the point Mr Charnley had made about night curfews. It was entirely consistent with the time-block concept: ie rather than have a 24h L_{eq}, day-time and night-time should be treated separately, and perhaps Sundays also treated separately. At sensitive times, rather than a limit of xdB, have a limit of none at all.

DR UTLEY, referring to Mr Charnley's question on fixed windows, said that the results of a survey he had conducted had shown that even where people were provided with alternative ventilation methods, they still liked to open their windows. He was not quite sure why that was so, since his questionnaire had not been able to go into sufficient detail to find out. It might simply be that people did not regard air which reached them through a mechanical device as being fresh. As he had mentioned, bedroom windows could be opened during the day when the room was unoccupied, in order to get free ventilation as opposed to the albeit fairly cheap electrically-supplied ventilation via a fan. In view of the findings about people's desire for open windows, Dr Utley considered it would be rather foolhardy to design dwellings with fixed windows.

On the point about noise from next-door neighbours, Dr Utley said that they could have designed a question to cope with that within the questionnaire; however, it had not been considered worthwhile, since it would have required people to cast their minds back six or seven years to what the situation had been like before insulation had been fitted. That raised many additional factors: eg whether the children next door had grown up, or whether the living patterns of the people next door had changed. However, he felt that the question of whether fitting insulation against external noise made people more aware of noise from their neighbours was an interesting one, although a very difficult one to investigate. Another complicating factor was the variability of types of walls and their insulation, as well as the variability of the noise made by neighbours. A very large sample would be required in order to average out such sources of variability.

MR VULKAN, referring to the point about background levels and adding new noise sources, said it was necessary to be very careful about the question of creeping incrementalism. A new noise source could be added which apparently was very similar to existing noise levels, but if other sources were added, the background noise level would gradually creep up and up. Another thing to be careful of was that if a new noise source had a different character to the existing background level, then even if it actually measured at a lower level than the background level, it could still be distinguished quite easily. The third element in the noise measuring system that Mr Sutton had mentioned - the pink box with the nose, ears and eyes, the human factor - was an important consideration. There were certain noises which people found more objectionable than others, and which could cause annoyance even at a low level.

On the question of different times of day, Mr. Vulkan expressed concern about the evening period. This was a time when people were likely to be at home, wishing to relax, watching television, or even preparing to go to bed. He felt that the period was not sufficiently considered either in the L_{10} 18-hour index, or more seriously in the NNI (Noise and Number Index). The NNI finished at 6 pm GMT (Greenwich Mean Time), which was 7 pm, British Summer Time. In the 18 hour index, evening noise was underestimated and in the NNI largely completely ignored. Although people might be willing to put up with a higher noise level by day, they were less willing to do so when they returned home in the evening.

On the question of curfews, Mr Vulkan agreed that they were the ideal solution. Whenever possible, there should not be noise at night. The problem lay in defining when night began, and in practical considerations. There had recently been arguments about that point in connection with the Stolport enquiry. The argument, on the operator's side, was always that an airport, or a factory, was not viable unless it could operate up until a certain time. In the end it was necessary to compromise between the particular use (Heathrow, for example, had to be used late into the evening - an argument Mr Vulkan reluctantly accepted) and, on the other hand, the protection of the environment.

MR C G HOWELL (NSCA, South West Division) wished to comment on planning policies and highway noise. Circular 10/73 advocated the adoption by local authorities of policies which would ensure that full weight would be given to the effects of traffic noise, when making decisions on planning applications for new housing development, hospitals, schools and other noise sensitive development. The principal aim was to keep such developments away from primary road networks, and other roads where noise was likely to build up to levels which might affect amenity. Where it was not possible to keep roads and noise sensitive development apart, the Circular advised that planning authorities should ensure, by appropriate conditions, that buildings were sited and designed so as to minimise the impact of traffic noise on them.

Mr Howell thought that the Conference might be interested in the standards adopted throughout Gloucestershire. Environmental Health and Planning Officers had produced a policy which had been accepted by all six District Councils in the County. The policy confined itself to new residential development, and changes of use and applied to existing roads, and committed new roads. Noise levels were to be assessed on calculations made on current or 15-year projected traffic flows. Circular 10/73 also stated that there should be a strong presumption against permitting residential development in areas which were, or were expected to become, subject to excessive noise - regarded as being levels in excess of 70 dB(A) on the L_{10} 18-hour scale. That level constituted the limit to the acceptable, rather than a standard of what was desirable, and local authorities were urged, wherever possible, to adopt a substantially lower value.
In Gloucestershire, the following levels were adopted without sacrificing other important planning objectives:

1. In respect of green-field sites, development should be prohibited on portions of such sites which are, or will be, subject to road traffic noise levels in excess of L_{10} 18-hour 65 dB(A).

2. Where development of sites within existing built-up areas, affected by road traffic noise levels in excess of L_{10} 18-hour 65dB(A), is proposed, the site design solution will be required to mitigate the effects of the noise, such that the level calculated to apply 1 metre in front of the exposed facades, is not more than L_{10} 18-hour 65dB(A).

3. Where it is impracticable to reduce the external levels to L_{10} 18 hour 65dB(A), or below, by site design options, the building specification should be

such that in habitable rooms the internal L_{10} with windows closed shall be no more than 40 dB(A).

Mr Howell said that he would be interested to know if anyone else had adopted such standards; if so, whether they had been successful, as in Gloucestershire, or whether they had encountered any problems.

DR UTLEY said that he had been doing a simple calculation: as he understood it, the maximum external level, even for houses with extra insulation treatment, would be 74 or 75 dB(A). On the basis of the Building Research Establishment's present results, that seemed to him not unreasonable. As he had mentioned in his paper, it was obvious that most people would prefer to be exposed to levels no higher than about 68 dB(A) L_{10}; with the pressure on land, in some cases exposure to slightly higher levels was inevitable. He warned, however, against the attitude that once the 70 dB(A) level had been breached, it no longer mattered how high the noise levels went so long as double windows were provided. At the very highest noise levels, even double glazing did not seem to provide what people would regard as a satisfactory internal noise environment.

MR VULKAN said that the GLC had established noise guidelines for external noise, but in the case of road traffic affecting housing, internal noise levels were used as the criterion. The GLC suggested that if new dwellings were built near a highway, the noise level inside the dwelling should not exceed 50 dB(A) by day in living rooms, and at night should not exceed 35dB(A) L_{10} in bedrooms. That guideline combined both site and the type of insulation requirements. However, he entirely agreed with Dr Utley that sound insulation alone was not enough, partly because people liked to be able to open windows, but also because the outdoor environment had to be considered. Insulation could not be provided for gardens, which were also an important element of the home.

MR D F CORFIELD (City of London) was critical of the

Noise and Number Index. He understood that it had evolved as a result of a social survey conducted around Heathrow in the late 1950s and early 1960s. At that time, the majority of aircraft were piston-engined or turbo-prop and turbo-fan without jet engines. As a recipient of complaints, Mr Corfield noted that most people complained about peak noise levels. However, most of the indices tended to average out peak noise levels everywhere. All the NNI did was to say that a certain number of people, between 1958 and 1962, had been annoyed by a certain number of aircraft. The modern interpretation of the Noise and Number Index was that people could be annoyed forty-five times a day, but that annoyance on sixty-five occasions during the day was too much.

Equally, with construction noise, it was no use working on the basis of an 8-hour L_{eq}. If someone complained at 11 o'clock in the morning, they would not be satisfied if one kept them waiting until six o'clock at night before one could tell them that, on the basis of the average noise level, a nuisance had indeed been caused. The complainant would round on the officer and tell them that they had known that at the time. The process of averaging out seemed to take no real notice of what noises really constituted a nuisance. At a time when international standards were being considered, Mr Corfield felt that it might be worthwhile to spend some time and money on looking back and reconsidering such things as equal loudness contours. They had been derived from a sample of between twelve and twenty-two people, which was hardly an adequate basis for an international standard. Mr Corfield asked for the speakers' comments.

MR SUTTON said that the Noise and Number Index did take peak values, as well as the number of incidents, into account. In fact, it was the only index in general use that took peak values, rather than time-averaged values, into account. According to the index, both a higher peak and a greater frequency would increase the index and therefore the nuisance rating. With construction noise, there was the problem of defining a "peak". The advantage of L_{eq} was that it was influenced by both peak and average values. It should not be necessary to take L_{eq} over the whole eight hours, and he agreed that the approach of basing legislation on 8 hr L_{eq} alone was a nonsense.

However, short-term L_{eq}s were workable and there was nothing in BS 4142 which would prevent L_{eq}s being taken for a period of five or ten minutes or an hour. Therefore, the impact of construction noise could be calculated over a one-hour period, even if the limit was set over a 6 am-to-10 pm period.

As far as equal loudness contours were concerned, Mr Sutton said that the A-weighting was in itself a form of equal loudness contour. Were equal loudness contours to be taken more seriously at lower noise levels, then perhaps the relative importance of low-frequency noise would emerge. The problem with equal loudness contours, or with frequency-block weighting methods, was that they were more laborious to use: dB(A) had the great virtue of simplicity. Since all the indices were imperfect, it was more sensible to pick a simple but imperfect one rather than a complicated, imperfect one.

DR UTLEY said that everyone liked having a go at NNI. The main problem was that the index did not cover a sufficiently long time period. Thus, if the evening flights at Heathrow were eliminated, it would make no difference to the NNI levels, which was a slightly absurd situation. However, since there was no question of removing evening flights from Heathrow, it was a purely academic point. On the basis of results from a survey which the Building Research Establishment had done in schools near Heathrow, he could say that there was a fairly good correlation between NNI and L_{eq}. Similarly, he believed that the National Physical Laboratory had shown the same high correlation in studies based on simulation of various situations involving aircraft noise.

Dr Utley felt it important to remember that behind the evolution of all the various indices was the drive to evolve an index which would explain the maximum amount of variability in individual response to noise. Each index had its own proponents, but it was interesting to note that when the correlations between particular indices for a particular noise source were examined, they were very high. Thus, there was virtually no chance of one index being better than another, and it would not be possible to make much progress by changing indices and looking for new ones.

Referring to peak noise, Dr Utley said that the problem of using this as a basis for control was that it was a very variable situation. With construction sites in particular, peaks produced would vary considerably from one day to the next. Were someone to complain about peak noise from construction sites (and he thought this unlikely: it was more probable that someone would complain after experiencing a number of peaks, in which case it would be all right to use L_{eq}) it would be difficult to exert any real control over the peak. By the time the complaint came in, it would be impossible to establish exactly what the peak noise level had been, unless monitoring was taking place continuously. He though it quite sensible to consider short-term L_{eq}s, as Peter Sutton had recommended, but he felt that using absolute peak levels as a method of noise control was impracticable.

MR VULKAN made a brief comment on NNI, saying that he had spent quite a bit of his time at various inquiries attacking NNI. However, he wished to defend the index in respect of peak levels. He pointed out that it was the logarithmic average, not the arithmetic average peak level that was used, which implied that the level in the formula was biased towards the noisiest aircraft irrespective of how many quieter aircraft there were.

However, he entirely agreed with Mr Corfield on the subject of averages generally. Quiet periods, however peaceful, did not compensate for noisy ones. One of his criticisms of NNI, apart from the fact that it did not cover the evening period, was that it was based on average mode, ie the average operation of an airport. Thus, aircraft could be routed over a particular school for a period of several weeks, yet this would not show up in the average mode of the airport's operation, particularly if that was calculated for the summer months. Thus, the school could be severely affected during the autumn by noise, to the point where teachers would be unable to teach, and yet the Noise and Number Index would not reveal the problem. Thus, while he agreed with the concept of NNI, he felt that its application as used in the UK was wrong. The UK was, incidentally, the only country which did not take night-time noise into account.

On the point about low-frequency noise, he believed that there were simple methods by which the impact of low-frequency noise could be rated. For example, were regulations on road vehicle noise to be specified not only in terms of dB(A), but also (in the case of lorries) in terms which stipulated that noise levels should not exceed so many decibels at, say, 100 hertz (100 cycles per second), it would overcome the low frequency noise identification problem. It was particularly important to be able to assess low frequency noise from traffic, because of its impact on people indoors, since windows transmitted low frequency noise more readily than higher frequency noise.

MR W F SNOW (Warrington BC) agreed with Dr Utley that the secondary insulation of windows was very effective in reducing the levels of traffic noise inside residential buildings. However, it did little to reduce vibration, and nothing to alter the problem of noise which affected gardens and other outdoor amenities.

He agreed with Mr Vulkan that planning was a very important tool in the prevention of noise problems. Unfortunately, however, environmental health officers' advice on the noise implications of projects was frequently given insufficient consideration by their colleagues in planning departments. In Warrington, there was a New Town Development Corporation, which, unlike the local authorities, seemed to have adequate resources for such matters as noise control; the Development Corporation went to considerable lengths to ensure that noise was adequately dealt with, consulting at an early stage with Warrington BC's Environmental Health Department, and using their expertise and advice in order to ensure that the development met adequate noise criteria before it was built. Only in one respect had the Development Corporation noticeably failed: they, along with everyone else, seemed unable to cope with the problem of motorcycle noise, and some of the new estates were plagued with the loud noise output from fast-driven or high-revving motorbikes.

In relation to Mr Vulkan's presentation and contribution to the discussion generally, Mr Snow expressed concern about the future of the GLC's Scientific Branch. Published Government proposals for the disbandment of the Greater London Council implied that the Scientific Branch would be lost, which Mr Snow said would be regrettable. Mr Vulkan and his team provided an inestimable service, not only to residents in the Greater London area, but (via the publication and discussion of their research findings) to the population as a whole.

Turning to the question of noise indices, Mr Snow thought it extremely unfortunate that there was no immediate prospect of the upgrading of existing noise standards. Picking up Mr Howell's point, Mr Snow said that the Environmental Health Officers of the eight Borough Councils in Cheshire, together with the County's own Environmental Health Officer, had drawn up noise guidelines for the County. Unfortunately, they had not always been able to persuade the District Councils to adopt and implement the recommended noise levels.

MR VULKAN thanked Mr Snow for his remarks about the work of the GLC's Scientific Branch. Obviously, there was concern about the future and he felt that some overall environmental service was essential for a major city. He was familiar with the Cheshire noise guidelines, which had been very useful to the GLC in providing a comparison with their own guidelines. In many respect, the two sets of guidelines were similar.

MR M J SQUIRES (Exeter City Council) asked whether the Panel considered that the scope of the 1975 Noise Insulation Regulations should be extended to cover traffic management schemes. He had two particular cases in mind (quite apart from such schemes as one-way traffic systems).

One had involved an excellent pedestrianisation scheme; however, as a result, traffic from what had been a very busy road was then routed through a formerly quiet, residential, access-only road. That had caused the residents great distress, but they had been unable to obtain any compensation through the Noise Insulation Regulations' mechanism. The other case was perhaps not quite one of traffic management; it concerned the development of a large industrial estate over a period of years. All the heavy traffic to and from that estate had been routed through a small village, which, until then, had experienced very little through traffic.

DR UTLEY said that presumably such schemes were introduced for the benefit of the wider community; it therefore seemed reasonable to compensate that small part of the community that would be adversely affected by the scheme.

MR VULKAN was delighted that the point had been raised. He said that it was a very great weakness of the Land Compensation Act 1973, and the 1975 Noise Insulation Regulations, that insulation could only be provided where there was a physical alteration to the road, or in the case of a new road. However great the increase in traffic, for example due to the construction of a new motorway and the resultant use of an existing road as a feeder road for the motorway, no compensation could be paid to residents living alongside the feeder road. Similarly, traffic management schemes did not allow for compensation in the case of increased traffic flow and resultant increase in noise levels. The Department of Transport had in fact examined the problem and had established a working party to review the Noise Insulation Regulations. Mr Vulkan had been a member of the Technical Sub-group. Many people favoured the provision of insulation in the case of traffic management schemes, where it could be shown that, due to a decision of the local authority, traffic along the road had been increased. The snag, as always, was cost.

MR J P GOSS (London Borough of Ealing) said that he and his colleagues in Ealing had looked very carefully at the use of L_{eq}, or sound power levels, for the assessment or limiting of noise. Referring to BS 5228, the Code of Practice for the Control of Noise from Construction Sites, Mr Goss said that one of the difficulties that he had encountered in the use of the Code was that the level specified in the regulations, 75 dB L_{eq}, was too high in situations where there were houses in close proximity to the construction site. Ealing's policy was to set a limit of 72 L_{eq} whenever they served a notice. So far there had not been an appeal against this level. Nevertheless, nuisance complaints were still received by the department even though the contractors were able to stay within the 72 L_{eq} limit on an hourly basis. Therefore, it seemed to him essential to seek a remedy in the Courts, on the basis of transgression of best practicable means, rather than use the BS 5228, which itself provided something of a defence. He felt that a move to the general use of L_{eq} could conceal some bad situations that could arise even when the L_{eq} levels were not breached.

Mr Goss said that no mention had been made of NR curves, or NC curves in relation to machinery that was likely to affect residential buildings. His department had experienced a great deal of trouble with air-conditioning and refrigeration plant, which could be installed in considerable quantities and operate at considerable volume in commercial premises. His aim in Ealing had been to permit the use of those machines to an NR curve of 35, measured at the nearest affected residential premises. He knew that that policy had its limitations, since obviously residential premises could, later, be constructed nearer to the site. Nevertheless, it was an attempt to tailor the use of indices to particular situations. Ealing also practised the use of differential L_{90}s in planning consents: they quoted a night-time L_{90}s. Indeed, his department would prefer to quote a three-part L_{90} to cope with the evening period as well.

Mr Goss added a word of caution about the blanket use of standard indices, which were not really appropriate to each and every situation. He envied Mr Howell his power to prevent the construction of buildings if there was a likelihood of traffic noise in excess of L_{10} 65 dB(A). Such a standard would more or less preclude development in most of Ealing. Thus, he considered that countrywide standards provided useful guidelines, but should be interpreted sensitively in the local context.

DR UTLEY was pleased to be the bearer of good news. A revised version of BS 5228 was likely to appear early in 1984. The 75 dB(A) L_{eq} figure did not appear in the document, nor did any other similar number. In the original document, the figure of 75 dB(A) L_{eq} had been inserted in an appendix, presumably with helpful intent. However, as usual people had taken a guideline figure far too seriously and treated it as a standard, and hence problems had arisen. In future, the trend in BSI noise standards would be to omit specific numbers. No doubt, the Committees would then be blamed for not providing sufficient guidance!

On NR and NC curves, Dr Utley thoughtthat these could be usefully applied to machinery noise, if the aim was to establish at which particular part of the noise frequency spectrum control was required. He was less certain about their applicability to the general noise environment. It was very difficult to get the curves to work with variable noises; they were really derived for use with a constant noise, such as ventilator noise in offices. He regarded the prospect of L_{10} or L_{eq} NR and NC curves with horror!

MR SUTTON thought that it was most important to distinguish between a noise index and a noise limit. In view of the trend the discussion had taken, he thought it was also necessary to distinguish more carefully between methods of measurement, recording and assessment, and the actual noise limit to be applied in any situation. He agreed that NR and NC curves were rather unwieldy; however, he thought there was value in the use of octave band measurements. Basically, he felt that, instead of NR 35, 40 dB(A) might just as well be used, with a pure-tone correction. That would probably give an even better degree of control. If one was seeking to identify the important frequencies within a total noise spectrum, the logical thing was to use A-weighted octave band values. They could conveniently be combined with an overall dB(A) limit. He had been using A-weighted octave bands for the last twenty years in the assessment of neighbourhood noise, and in cost benefit studies related to industrial noise. He strongly advocated their use.

SESSION SIX

ENVIRONMENTAL PROBLEMS ASSOCIATED WITH THE SMALLER INDUSTRIES

IRON FOUNDRIES AND NON-FERROUS MELTING

T Townsend, Wolverhampton Metropolitan Borough Council

SCRAPYARDS AND THE RECOVERY OF METALS FROM WASTE MATERIALS

C Brookfield, Sandwell Metropolitan Borough Council

OFFENSIVE TRADES

O A Dodds, Bristol City Council

MR F G McQUEEN (South Tyneside BC) thanked speakers for three very practical and thought provoking papers. Having heard them, his principal conclusion was that he did not want to work in the West Midlands!

Referring to Mr Townsend's and Mr Brookfield's comments about lead in relation to the use of pirate waste oil, he said that the situation could be a cause for concern. He asked whether monitoring was carried out around plants known to be using that material, to determine the effect on air quality. He also asked whether Mr Townsend could expand on the question of soil contamination.

Secondly, he asked Mr Dodds whether he considered that the spreading of pig slurry on land should be included in the list of "offensive" processes. It was a considerable problem in the South Tyneside area.

To all three authors, he commented that they had each indicated their belief that local authorities were handicapped by having to prove nuisance before action could be taken against various processes under the Public Health Act. He asked them what alternative provisions they would prefer should they have the opportunity to make radical changes to the whole body of clean air legislation. He wondered whether perhaps the speakers would see some advantage in the system of Codes of Practice, similar to those published under the Health and Safety at Work Act. Alternatively, he asked whether perhaps the panel might consider that such Codes would be impossible to produce, because of the complexity of the industries involved. Mr Brookfield had hinted at an alternative means of control, under the system of the three yearly renewal of scrap merchants' licenses. He asked whether perhaps the speakers would consider carefully worded conditional licenses as a possible means of controlling those industries - where it was an absolute offence not to have a license, and the local authority had the discretion to withdraw or withold the license. In his view, a major problem with the use of BPM was that one could apply them to a new industry, but ten years later, they would be out of date.

CLLR S MARTIN (Oxford City Council) said that he had been both interested and appalled by Mr Brookfield's paper. He had spend his working life in the reclamation industry, principally as a rag merchant, but also dealing with various ferrous and non-ferrous metals, paper and other scrap. The picture Mr Brookfield had painted of conditions in the West Midlands reflected disgracefully on the reclamation industry, of which he himself was proud to be a small part.

Mr Brookfield had mentioned the need for greater attention to be paid to health, and Cllr Martin agreed with this, saying that he felt that closer examination would reveal some "interesting" but dreadful effects. In the case of itinerant scrap dealers, for example, there were many incidences of early deaths from a wide variety of cancers. He was certain that practices such as cable burning, hand-sorting of fragmentiser waste, hand-breaking of batteries and then using the cases to boil washing in, were a major cause of the cancers.

In his view, the local authority attitude towards the health aspects of these practices was regrettably negative. Elected members were more concerned about the complaints they received, which they immediately passed on the the EHO rather than visit the scrap yards themselves. Councillor Martin thought that was the coward's way out. Councils tended to see their relationship with the reclamation industry in terms of public relations rather than pollution control. On a net scale, the reclamation industry was a remover, rather than a creator, of pollution. The reclammation industry contributed to the removal of millions of tonnes of unwanted household wastes and wastes such as old cars, dumped in the countryside.

He thought it most undesireable that the West Midlands should become the equivalent of the Phurnacite plant in South Wales, producing pollution in a relatively concentrated area, for the benefit of the UK community as a whole. It was the job of local authorities to come down hard on polluters; tightening up the Scrap Metal Dealers' Act was one possibility. However, he felt that the essential first step was greater co-operation between the local authorities and the industry.

It was wrong to look at the problem in terms of an electoral gain or liability. It was wrong to build houses next to scrapyards, and to achieve relocation without compensation was thoroughly wrong. Councils were displaying a thoroughly negative attitude towards a valuable industry, which, if it was treated with greater respect and kindness, would react accordingly. Many of the small firms had working bosses, who would be greatly concerned about their own and their families' health if only they had more information about the risks they were taking. To view scrapyards simply as a pain in the neck was a negative, and in the long run, counter-productive approach.

CLLR R KIDD (Newtownabbey BC) wished it to be known that he very much appreciated the efforts of the NSCA staff at the conference and their willingness to help delegates with any queries they might have.

Turning to the discussion on problems with smaller industries, Cllr Kidd referred to a cement works in his area which, some years previously, had caused tremendous problems. He felt it no exaggeration to say that the fall-out was so heavy that it was possible to get a nice new concrete path simply by putting out wet, sharp stones at night and waiting for the fall-out of cement from the plant on to the area. Eventually, money had been obtained to improve the plant to the point where it took two nights to create a nice new concrete path. Now, however, the situation was deteriorating again.

Elsewhere in the area, pollution had been contributed by ICI and Courtaulds, notably by the works sewerage plant: standards were not maintained at the factory plants and as a result, Belfast Lough was polluted. The improvement came when those factories had closed down, which was a sorry way to secure environmental improvement. Mention had been made that morning of taking legal action against polluters; Cllr Kidd considered that that could only happen when someone broke the eleventh commandment, "Thou shalt not be found out". He thought that one possible solution would be for enforcement officers to require operators to supply an inventory of their plant, showing the depreciation and the funds equal to this depreciation in a plant fund to provide replacement. Thus when equipment deteriorated with age and use, becoming inefficient or worn down, the enforcement authority could require it to be replaced using a specific fund within the company's overall resources. That would overcome the usual objection about lack of money to carry out improvements.

Money was always a problem, and had affected Northern Ireland in relation to the implementation of smoke control, one simple reason being that Northern Ireland lacked the advantage of North Sea gas. Natural gas had been witheld from the Province by a political decision. In his opinion Northern Ireland suffered from many pollution problems. Many people said that it would be impossible to secure really clean air in the Province, but he did not think that anything was impossible, providing that people used their ingenuity as well as their will to bring it about.

MR B P HANNA (Belfast City Council) said that he had been interested by all the papers, but particularly the one on offensive trades. He felt that Mr Dodds' conclusions were very helpful. Were there to be changes in legislation along those lines, it would be a move forward. However, he considered that Mr Dodds could have paid greater attention to the planning aspect. In his view, if the business was in the wrong place to start with, any additional control mechanisms would be less than adequate. In his own authority's area, there was a problem rendering plant in completely the wrong place. The local authority had tried every means of control: they had served notices, become involved in legal proceedings, and all the time the company had been completely co-operative in the attempt to improve matters. The real problem was that residents would be satisfied with nothing less than almost total abatement of the odours. He asked Mr Dodds whether, in such a case where the nuisance persisted in spite of full co-operation from the company, he would advise local authorities to take High Court action, bearing in mind that, in the light of High Court judgements an injuction was extremely unlikely unless willfull negligence could be proved. As a supplementary question, he asked Mr Dodds whether he was aware of any such judgement in relation to offensive trades.

DR L E REED (HM Industrial Air Pollution Inspectorate) said that he had found the account of the problems of smaller industries extremely useful. Mr Townsend had stressed the importance of co-operation between the local authority and the Industrial Air Pollution Inspector. Dr Reed was also pleased to hear that Mr Townsend sometimes found it difficult to contact his local inspector; that probably meant that the Inspector was out on the job. He could not exercise much control if he was desk-bound. However, he would become concerned were Mr Townsend unable to contact the Inspector directly.

Dr Reed emphasised that both local authorities and the Inspectorate had statutory responsibilities for the control of air pollution. There was great benefit in co-operation and regular contact. He hoped that local authorities would draw attention to any problems they were experiencing with registered works, and he would certainly be happy to advise the local authorities and he noted that Mr Townsend had regretted the non-introduction of the second set of grit and dust regulations, which would have covered that process. Dr Reed wished to point out the acute difficulties there were in measuring the emission of grit and dust from cupolas, and he questioned whether further grit and dust regulations would be of any help.

Dr Reed wondered whether BPM powers would really solve Mr Townsend's problems. Obviously, they would be very useful in relation to new plant, since the local authority would be able to give prior approval and set conditions accordingly. However, with existing plant, Dr Reed considered that BPM might be difficult to apply, particularly in the absence of an agreement by industry as to what the best practicable means were.

Mr Brookfield had stressed the problems resulting from the burning of cable to recover metals. Dr Reed was familiar with these problems, which had formerly been the responsibility of the Inspectorate. The Inspectorate had, in fact, prosecuted on 37 occasions in 1981 for cable-burning offences. In order to prevent cable burning, it was necessary for all sides - the local authorities, HMIAPI and the public - to be vigilant; the Inspectorate would do what it could to help local authorities now.

MR S CARDEN (Barnsley MBC) added his congratulations on the speakers' refreshingly honest and straightforward presentations. Mr Carden considered that, too often, speakers were complacent about their achievements in the field of air pollution control, and that, at present, local authority Environmental Health Officers were "weak opposition" when it came to enforcing the law. During the panel discussion on Tuesday, Mr Carden had asked the DOE representative when the promised review of clean air legislation would result in new powers to deal with such problems as night time "bus burning". He had considered that the reply he had received had been most inadequate. He reiterated his plea for new powers, which he said were urgently required in order to improve the quality of life. With such problems as bus burning, the local authority was dealing with the criminal element, and being forced to use powers that were outdated and inadequate. Were a local authority Environmental Health Officer to catch someone in the act of illegal cable burning, it would still be necessary to get the address of the individual in order to take further action. If the address was brusquely witheld or falsely given, it was very difficult to serve a summons and get the offender to court. In such circumstances, nothing short of powers of arrest would deal adequately with the situation. That would be a drastic step for local authorities, and one with which they really could not deal under the present set-up - but it was the only real solution. He asked the panel to summarise the main areas in which they would like to see new powers given to local authorities, and to give their views on what measures might be taken in the meantime.

MR R C WEBB (Cheltenham BC) referred to the statement at the beginning of Mr Dodds' paper on offensive trades that: "their operations present unique difficulties, the control of which has caused severe problems to local authorities for many years." If anything, Mr Webb felt that to be an understatement of the case. He considered that areas without offensive trades were very lucky indeed. His own view of offensive trades was coloured by his experience with a fat rendering process. It had taken five High Court hearings (the last in the Court of Appeal) before the rendering factory had finally been closed. He warned against any view that action in the High Court would provide a speedy solution. In his own experience, judges would suspend a final decision until all attempts at a remedy had been exhausted. Such action also consumed considerable resources, both within the authority's environmental health department and in its legal department.

He asked Mr Dodds whether the best practicable means for coping with the storage of carcasses of meat and offal from abattoirs and knackers' yards could include storage under refrigerated conditions. That would reduce the possibility of odour, since it would keep the carcasses a and offal fresh. Refrigeration could be extended to the transport, as well as the storage, of the raw materials.

His second point concerned planning. Mr Webb said that many offensive trades were on valuable re-development sites, and yet their presence sterilised the land around from any further development. He wondered if there was any possibility of money from central Government which could be used as an incentive to the operators of existing offensive trades, to encourage them to move to more suitable locations. He felt that the problems caused by offensive trades deserved to be tackled on a national basis.

MR J CLEGG (Manchester Area Council for Clean Air and Noise Control) referred to Mr Townsend's comments about a DOE grant which had been given towards the fitting of a new grit arrestor. Such grants were properly available under the inner urban programme, and Bolton had negotiated a similar grant to enable pollution control to be carried out in a problem foundry. Bolton had also negotiated other schemes in relation to noise. Nevertheless, he was concerned about the DOE's lack of enthusiasm for such schemes. They preferred to make grants towards projects which would result in visual improvement to the area: painting buildings, planting trees etc. Mr Clegg considered that a short-sighted policy and felt that DOE should be more positive in its encouragement of pollution control, and should promote grant aid for such schemes. In times of recession, such grants were symbolic of a proper, partnership approach to improving pollution abatement and protecting existing jobs. The apparent conflict with the typical operation of the Polluter Pays Principle in the UK did not worry him, since ultimately the community financed pollution control (as taxpayer or customer of industry); otherwise the community suffered if pollution control was not implemented.

The second question concerned the application of tall chimneys to cupolas. He asked whether these had been effective in reducing nuisances of grit, dust, fume and smell.

MR R H SHIPMAN (BP Oil Ltd) wished to respond to Mr Brookfield's comments on the burning of waste oil in furnaces. He emphasised that BP and the oil industry generally did not at all approve of this practice. When questioned on the subject, BP's response was to draw attention to the fact that waste oil was a contaminated product: it might contain lead from petrol, or motor spirit additives, and raised problems not only of health, but also of safety if the waste oil was burnt in an uncontrolled manner. Disposal of waste oil was a problem, in the manner described but burning it was not the answer.

MR C G HOWELL (NSCA, South West Division) had been interested by Mr Townsend's comments on divided blast cupolas and low frequency noise. In his area, fairly recently, a small iron foundry had replaced obsolete cupolas by a pair of divided blast ones. Within weeks of their commissioning, residents in houses some 300 metres away had begun to complain of rattling windows and doors, crockery bouncing around on the table etc. The only solution so far found was to tune the air supply, rather as one tuned the carburettor of a car. Unfortunately, the beneficial effects were short lived and could only be maintained by very good housekeeping on the part of the company. He wondered whether Mr Townsend had any other solution to offer.

CLLR W P URMSTON (Warrington BC) mentioned a particular problem in Warrington with a nail galvanising plant. The only pollution control equipment fitted was a filter unit; therefore, all the waste gases were emitted as a fume. In response to the authority's demand for further pollution control equipment to be installed, the firm had threatened to cease production and import from abroad, which would mean the loss of jobs in the area. He wondered whether Mr Townsend knew of any cheap method which could be used to eliminate the fume.

Cllr Urmston had a personal interest in the problem: not only did he work for the firm, he lived near to it and the firm was situated in the Ward he represented.

MR T TOWNSEND, replying to questions raised during the discussion, dealt first with the point about soil contamination raised by Mr McQueen. Mr Townsend said that the situation was somewhat confused at present. Wolverhampton undertook soil sampling and were finding very high levels of metals on their sites, but what they did not know was over what period the deposition had occurred. They rather thought that it might well have begun the previous century as levels were fairly constant to a depth of up to 1 metre. Remedial work normally entailed stripping the soil off to a depth of 1 metre and bringing in fresh top soil which was uncontaminated. In most cases both the sampling and restitution of the site was funded by Derelict Land Grant.

On the monitoring of airborne lead levels, Mr Townsend said that Wolverhampton and the other Black Country authorities had been engaged in the continuous monitoring of heavy metals since 1977, there being seven monitoring stations within his own authority's area. They were positioned in different situations, including fairly close proximity to foundries. Commenting on the levels found, Mr Townsend stated that he personally did not consider them that high. Average lead levels, for example, in the urban/residential parts of the town were in the order of 0.3-0.4 ug/m^3. Close to the foundries they were about 0.5 ug/m^3. Thus whilst there was a slight increase close to foundries, when assessed against the EC Directive standard of 2 ug/m^3, there did not appear to be a tremendous problem.

On the question of desireable changes in legislation Mr Townsend said that he favoured the idea of Codes of Practice, linked to a system of prior consents. Speaking of prior consent in relation to Dr Reed's question, he said the essential thing was to determine the standards that had to be applied to the industry from the outset. That could be done in co-operation with the industry under the Code of Practice system. He felt that standards for many different processes could be satisfactorily arrived at through a co-operative approach between local authorities, the industry concerned and DOE. It would be hard work but he believed it would prove worthwhile.

Mr Townsend stressed that the threat of physical violence in relation to the control of some processes was very real. He knew that Mr Brookfields telephone number was ex-directory as were the numbers of two of his own staff, and he did not think it would be appropriate for elected members to face the same risk. It was the officers' job to advise the members of the problems and the members' job to decide on a policy that would overcome these problems.

Turning to Dr Reed's point about contact between the local authority and the District Inspector (HMIPAI) Mr Townsend said that he appreciated that the Inspector's job was to be out working on the district and that generally there were few problems in maintaining adequate contact between the local authority and the Inspectorate.

Referring to the publication of the Report of the Second Working Party on Grit and Dust and his reaction to it at the time, Mr Townsend said that it had caused him mixed feelings. Originally he had welcomed the proposed Regulations as a means of raising pollution control standards in the industry. However, time had modified this view and it now appeared obvious that their introduction may have resulted in the loss of even more foundries than had been lost due to the recession. Nevertheless at the time of the Report the foundry trade had been involved in the appropriate discussions and no doubt would have been in a position to meet the standards set. Certainly his local authority had geared itself to the necessary monitoring requirements and one of the advantages of the tall chimneys policy was that it provided a satisfactory measurement point. It was of course impossible to carry out meaningful grit and dust sampling by attempting to use a probe across the top of a wet arrestor.

On the subject of DOE grants he was pleased to hear that Bolton had come to a similar arrangement, but still felt some concern over the principle. One firm had applied to the County Council for grant aid to install pollution control equipment and the County Council's response had been to put the burden of need back onto the District Council, requiring an undertaking that if the equipment was installed no further action would be taken over future emissions. He felt that this was not a particularly helpful development as such an undertaking could compromise the District Council as the pollution control enforcing authority.

On the question of the effectiveness of fitting tall stacks to cupolas Mr Townsend said that they were effective in preventing nuisance. The emission of fume from a wet arrestor fitted cupola at a height of 65 feet would inevitably cause problems to residents of any nearby houses. Naturally, the overall level of emission was not reduced, but since part of the UK policy on air pollution control was also based on dispersal this had seemed an acceptable solution. The authority had however seen it as an interim measure to be used until the fume cleaning measures which they had anticipated were brought into force.

Taking up Mr Howell's point about twin blast cupolas and noise problems he said that Mr Howell had hit upon the correct solution. It was necessary to vary the speed of the fans, but he was a little surprised at Mr Howell's comment about the short term nature of the remedy and considered that regular inspections of foundries and liaison with the maintenance engineer would ensure that the message was got over.

On Councillor Urmston's point about galvanising fume Mr Townsend agreed that it was a problem; the solutions he suggested were:

Cutting down on the ammonium chloride flux. That could be done by the introduction of compressed air salt guns, which initially reduced the amount of fume given off. Of particular reference to the nail industry was the beneficial effect of pre-fluxing by dipping into a zinc/ammonia solution before immersion into the galvanising bath.

MR C C BROOKFIELD said that as far as the majority of scrap dealers was concerned, changes in air pollution legislation would make little difference. In his view the only hope for improvement lay in the extension of licencing, under the Scrap Metal Dealers' Act, 1964, to include conditions related to environmental matters including height of piles of material, landscaping, surfacing of yards, drainage, collection points for acid, conditions relating to burning and other matters which the Local Authority might consider necessary. Abattoirs and offensive trades were licensed, thus the idea was not unprecedented. Unlike much of the rest of industry there was very little self regulation within the scrap metal trade. Of the 10,000 scrapyards within the UK only 450 (4.5%) were members of the British Scrap Federation, those, on the whole, being the larger more reputable companies, and only 2 of the 80 yards in Sandwell were members.

On the question of the use of waste oil in furnaces, Mr Brookfield stated that there was now a disreputable element involved in the processing and sale of waste. He knew of one instance where a man toured round in a large van with a 500 gallon tank in the back. He went round to garages saying that he was a road surfacing contractor, asking each garage for "a couple of gallons of waste oil to heat my shovel up". What usually happened was that the garage owner, given a couple of pounds, would direct him to the waste oil tank at the back of the garage and tell him to help himself. He would then proceed to pump as much as 500 gallons of waste oil into his tank and off he would go. The oil was subsequently put into drums and allowed to settle, this being the only treatment the oil would receive before being resold. Analysis of such oil in America has revealed lead contents of up to 2% This was the sort of material which he suspected was being use used in scrapyards, brick kilns, and forges throughout the West Midlands; the problem was in finding the stuff.

Referring to Councillor Martin's comments, Mr Brookfield said that there was a particular problem with gypsies, in that children were employed in collecting and processing scrap metal. He had seen gypsy children in scrapyards an and at the back of a foundry with buckets collecting dross. Fires were started to burn cable and the dross put onto the fire in an attempt to melt out any bit of aluminium they could. It was quite appalling to think of the risks those children were being exposed to. It was a matter for the Health and Safety Executive to attempt to deal with, but he did not envy them their task. It would be very difficult to carry out, for example a blood/lead survey on the itinerant population even if they were to agree to it. In response to Mr McQueen's question about monitoring, around a works which was known to be using waste oil, Mr Brookfield stated that the main stumbling block to extending his Authority's heavy metals monitoring programme was cost, but that if a particular problem was suspected then further monitoring would have to be considered.

Referring to the question of the recovery of copper from cable in furnaces now being registered with HMIAPI, Mr Brookfield was of the opinion that this would effect little improvement. Without wishing to imply any criticism of HMIAPI, he felt that the idea of attempting to enforce on the average scrap dealer the emission of limits for hydrogen chloride was unrealistic. Were an inspector to go into a scrapyard and tell the owner to spend a four-figure sum on wet scrubbers, in order to reduce hydrogen chloride fume to 0.2 grains/cubic foot, in many cases he would not receive a polite reply; the response would be that cable would be burnt in the open, rather than in furnaces and usually after dark as was already the case.

On the question of violence at scrapyards, Mr Brookfield said that Local Authority officers certainly did not seek to provoke violence; their function was to enforce law and offer help and advice. However, if they met with violence in the course of their visits, then the appropriate action had to be taken. He and other members of his air pollution control staff had been threatened by scrap dealers in no uncertain terms.

Mr Brookfield hoped that the work commenced by Steven Simmons at Aston University into heavy metals emissions from foundries could be continued and hoped that some work could be done on the use of waste oil.

MR O A DODDS agreed with Mr McQueen that the spreading of slurry (pig manure) should be included in the list of offensive trades. In relation to the spread of slurry on land generally, many of the problems originated with the Regional Water Authority, so that any control applied to the spreading of pit slurry should logically also be extended to other forms of slurry spreading and this might prove to be difficult.

On the question of possible alternative legislation to replace the "nuisance provisions" of the 1936 Public

Health Act, Mr Dodds felt that the answer was so broad that it would require a paper to itself. However, he hoped that his paper and presentation had indicated the direction he felt the changes should take, and the speed at which they should be made, and in view of the shortage of time, suggested that the speaker see him later for a more complete discussion of the issues. On the subject of planning liaison, he agreed that consultation had to be done properly and, even then, problems could still arise and he would not offer 'off-the-shelf' solutions.

So far as relocating offensive trades was concerned, he thought it would be difficult to justify to the council the payment of what might be substantial sums in order to relocate a particular works especially where the problem had been created through the planning process. In these circumstances he felt that the "planning process" should pay; but the problem was, that the same public purse paid, in any event. He believed that all those involved in planning decisions had to consider the economic and nuisance implications very carefully when dealing with such applications. On the transportation of materials from knackers' yards, he agreed that in some circumstances refrigeration would be the best practicable means, expensive as it was.

SESSION SEVEN

MAJOR ENVIRONMENTAL HAZARDS AND THE PROTECTION OF THE COMMUNITY

INDUSTRIAL MAJOR HAZARDS AND THE PROTECTION OF THE COMMUNITY

E A Ryder, Hazardous Installations Policy Branch,
Health and Safety Executive

LOCAL AUTHORITY INCIDENT RESPONSE - THEORY AND PRACTICE

M J Gittins and R S Wright, Leeds City Council

MR S CARDEN (Barnsley MBC) said that it had given him particular pleasure to open the discussion, since he started work as a student public health inspector in Morley Borough Council, under Bob Wright. He had learnt a lot from Mr Wright then, and had learnt more from the presentation that day. In his student days, he had known the Woodkirk area well; Mr Wright's talk reminded him of its importance as the rhubarb growing centre of the world!

Mr Carden thought that Mr Ryder had given some good news on the proposed amendments to planning legislation. While the UK Notification Regulations were relatively new, it looked as if a wider range of hazardous processes would be covered under EEC legislation, according to the proposed directive. He wondered whether Mr Ryder would like to see the directive list incorporated into the UK Notification Regulations, or indeed whether he would like to see any other amendments to existing legislation.

Referring to the cost of compliance with environmental standards, Mr Carden mentioned the exceptions (referred to in Session 6) to the principle that the polluter should pay, brought about by the industrial improvement area procedure. He asked the speakers whether they considered that, in the current times of recession, the same sort of exception should be made in respect of safety requirement requirements.

MR K G KAUFMAN (Tameside MBC) asked Mr Ryder whether he was satisfied with the level at which the Notification Regulations had been set, i.e. the triggering agent in terms of the amount of flammable liquid stored on site. Mr Kaufman referred to the Chemstar plant in Tameside, which had suffered an explosion and subsequent fire two years previously. That firm recovered contaminated solvent by distillation. The explosion and fire had involved over 30 fire tenders and over 300 men, and had been the biggest fire dealt with by the Greater Manchester service in 20 years.

The entire village of 1,000 people had been evacuated; the nearest house had been only ten yards from the plant. Hundreds of 45 gallon drums of solvent had been propelled 100 feet into the air like rockets. However, at the time of the fire, there had been a total of only 720 tonnes of flammable liquid on the site. 10,000 tonnes was the required notifiable level in the Regulations. Thus, had Chemstar been 14 times bigger an operation, it would have been covered by the Regulations.

Although one man had been killed, and another injured, it was Mr Kaufman's opinion that it was by the grace of God and the expert work of the fire authority that a far larger incident had not occurred, perhaps involving every building and every person in the village.

He agreed that the amount of material stored was important, but wondered whether Mr Ryder would agree with him that the method and site of storage were also important, as was the nearness of dwellings and other buildings to the storage site. He assured Mr Ryder that the storage of 720 tonnes of flammable liquid within 10 or so yards of a person's home was considered a major hazard by all the people living in that village.

CLLR N TAGGART (Leeds City Council) referred to Mr Ryder's remarks about the Morley-Woodkirk incident; in particular, that because of some of the details of the case, there had not been an inquiry into the incident. As an elected representative, he found that attitude unacceptable.

Referring to the fire and explosion at the works of D and R Hauliers at Salford in September 1982, Cllr Taggart said that in that case, the Health and Safety Commission had instructed HSE to make a special investigation and submit a report for publication which would be available for purchase by the public. However, such had not been the case with the Morley-Woodkirk incident. He felt that the fears of people in the areas would be somewhat allayed were there to be a proper inquiry, conducted publicly and openly and initiated by the Health and Safety Commission (whether or not they considered that they had such powers). The only acceptable level of such an incident was, Cllr Taggart considered, a nil level. Such an inquiry would benefit not only the people affected, but also the wider community, in terms of drawing out general lessons and guidelines which might help to prevent such incidents in future.

MR I W BARKER (Sheffield City Council) asked Mr Ryder whether he subscribed to the spirit, as well as the letter, of the proposals for the amendment of the Notification Regulations and the proposals contained in the draft EEC Directive. He had in mind a particular incident which had caused a considerable amount of concern to his local authority. The incident, which had

Whether or not the environmental health department and the councillors were satisfied with the way the incident had been handled, they had a wider duty to allay the fears of the public on the matter. If an incident occurred which had not only an immediate effect, but effects on the environment for months or even years to come in terms of contaminated vegetation and streams, then, for the sake of those who had to put up with such degraded conditions, all possible steps should be seen to have been considered and taken by those in authority - whether the local council or the Health and Safety Commission. People wanted reassurance that such an incident could never occur again, and also that all the lessons that could be learnt from the situation had been learnt.

involved an explosion in a valve chamber on a petroleum pipeline owned by a national pipeline agency, had been brought to the attention of a local councillor by a constituent, the mother of a child who had been injured at the scene, some three weeks after the event.

The mother had approached the councillor because she had been unable to find out why the incident which had burnt her child quite badly, had occurred. She could not find out what measures were being taken to investigate it, nor could she find out what measures were being taken to avoid a repetition. Eventually, the matter had been passed to the Environmental Health Department which had sought details from the local HSE Inspector.

Some four weeks later they had received the details, but with the rider that, while HSE was willing to provide such information, it did not see what it had to do with the local authority. The elected member, and the local Member of Parliament, had been somewhat incensed by that reply. Eventually, Mr Barker had written to HSE headquarters and made a report on the matter to the Environmental Health Committee. The response from HSE headquarters had been dismissive and somewhat cavalier, as a result of which the Environmental Health Committee had sent a strong representation to the AMA, HSE and to local Members of Parliament. Some eight months after a formal reply had emerged from HSE. That reply was no less dismissive and no less cavalier in its tone, saying in effect that such matters were for HSE to deal with, that they saw no need to notify the local authority on every occasion about incidents that might or might not cause local concern; and that were the incident to be of any local importance, no doubt the local authority would eventually be informed by the Fire Brigade (if it attended the incident).

Mr Barker reiterated his question, as to whether Mr Ryder subscribed to the spirit of the proposals so far as they related to liaison and consultation.

MR J B DOUGLAS (NSCA, North West Division) asked Mr Ryder how flexible HSE were prepared to be in standardising or amending the proposed list of substances. In Mr Douglas's opinion, there was one glaring anomaly between the two sets of Regulations. The Notification Regulations included within their scope anyone holding 15 tonnes of sulphur trioxide. Yet, in his own area of St Helens, the there was a plant making bulk liquid SO3 from oleum in a built-up area which, according to the Regulations, would not necessarily have to have a safety policy.

MR E A RYDER said that all the comments and queries had made his visit worthwhile! Final decisions on policy were made by the Minister, on the recommendation of the Health and Safety Commission. Local authorities had a say in the appointment of two members of that Commission; therefore, there was a route for local authority representations.

Mr Ryder confirmed that the Notification Regulations, and the regulations which would implement the EEC Directive, did contain different lists of substances. His own view was that the two lists should be more closely aligned, so that they were nearly the same, if not identical, although there were particular peculiarities in the EC Directive list. One difficulty with the Directive as it stood, was that a particular distinction was made for isolated storage - there was provision for relaxation of controls in relation to a particular substance if it was stored in isolation. Mr Ryder found that a little absurd. He thought that the simpler procedure under the Notification Regulations was preferable, ie, to determine a particular interest by the amount of a substance stored. Subsequent inspection could determine whether safety measures were satisfactory, whether many precautions needed to be taken, or whether indeed it was just a heap of materials in a stone, fire-proof building, isolated from all other materials.

On the point of whether the Polluter Pays Principle should be tempered by economics, Mr Ryder felt that it should not, and that to do so was a bad, short-term economy.

On the point about whether the levels in the Notification Regulations were set sufficiently low, Mr Ryder said that they had, or necessity, been set arbitrarily, largely on the advice of the Advisory Committee on Major Hazards, which had examined all the evidence and tried to allocate threshold levels for the various substances, so that there would be some equivalence of hazard. It was a very difficult thing to do. It was certainly possible to allocate equivalence of hazards amongst substances that would explode; TNT equivalent could be roughly calculated. However, it was much more difficult to compare the seriousness of an explosion with the seriousness of a toxic release. Yet, legislation had to be black or white and a line had to be drawn somewhere.

The Chemstar incident had indeed been rather alarming, with the nearest house a mere ten yards away (probably inhabited by the local environmental pressure group leader: such people usually had some reason to chair a pressure group). Mr Ryder understood that when the works had originally been built, back in Victorian times, the house had belonged to the mill owner. The Chemstar incident had resulted in a spectacular, but simple fire. The only person killed had been an employee at the plant, and the injured person had been his co-worker at the scene of the incident. A fairly large quantity of flammable material had been present, but stored in small loads (45 gallon drum containers). He did not think that that incident alone justified the argument that the level set for that sort of flammable liquid in the Notification Regulation was wrong.

He believed that inventory was certainly important, and had already explained why HSE believed that the easiest way to apply those controls was to take inventory as the first and only parameter in setting the specifics of the controls. Location was important, but was a subject for planning controls. He wondered whether, in this particular case, houses had always been so close to the site from the time of its present use, or whether housing had just grown near the plant subsequently. Perhaps both had occurred, before planning controls had been evolved which could prevent such a situation. He was not sure that the country as a whole would be prepared to pay the cost of remedying such a difficult situation. What could be done was to ensure that the mistakes of the past would not be repeated in the future.

Referring to the Morley-Woodkirk Paraquat-Diquat release in a fire, Mr Ryder had said that it had not been a major accident within the terms of the Directive, although clearly, for the people involved, it had been very disturbing. Many such accidents were. The technical difficulty for the Health and Safety Executive was that the Health and Safety at Work Act did not really deal with environmental matters of that sort. There appeared to have been no direct or actual injury to people, and the Health and Safety at Work Act was concerned primarily, indeed only, with the safety of persons. Thus, he could not have expected his own organisation to have gone further than it did.

Mr Ryder said that he was not very familiar with the details of the Sheffield incident described by Mr Barker. He did not know what the boys were doing playing where they were; he did not know why there had been a leak or why there had been a fire. As a general principle, he regretted the fact that Mr Barker considered there to be poor liaison between the Environmental Health Department (in Sheffield) and the Health and Safety Executive. He offered to take the comment back and see if the situation could be improved. However, he was absolutely clear that the Health and Safety Executive was committed to the spirit of any legislation that it had to enforce.

Referring to Mr Douglas's question on the degree of flexibility there would be between the list of substances in the Notification Regulations and the regulations which would implement the EC Directive, Mr Ryder said that he had put his finger on one of the anomalies. The Directive contained a number of such anomalies. It contained differences in approach and in definition, and inconsistencies in some of the substances that it listed in its various schedules. The consultative document on the implementation of the Directive noted that the approach differed from that in the Notification Regulations, and indicated that a further consultative document would be issued, which would discuss the differences and indicate proposals for overcoming them or aligning them. HSE would welcome comments on that particular aspect.

MR M J GITTINS said there were just three points raised which he and Mr Wright wished to comment on. The first was on the question of whether the polluter actually paid. As far as the Woodkirk incident was concerned, the Local Authority view was that the polluter certainly had not paid. Leeds City Council had had to pay about £1,000 to remove paraquat and diquat that had contaminated the public highway as a result of the incident. When they had submitted that account to the company which operated the warehouse where the fire had occurred, they had been told that, as the local authority had not acted at the request of the company, the company was not liable to bear the costs. The local authority had resubmitted the account, and was still trying to get the money reimbursed, either by the company or by the manufacturer of the herbicides. They could not see why the City Council should carry the costs.

As to whether a single quantity of material was a reasonable criterion in the Notification Regulations, Mr Gittins felt that there was room for a sliding scale, relating not only to a quantity of substance, but also to a scale of distance i.e., how far away from the site the nearest sensitive property was. He considered that possibly the same criteria should not apply to sites where houses were at some hundreds or thousands of metres distance, as applied to those with houses on the curtilage.

Thirdly, Mr Gittins said that both officers and elected members in Leeds believed that HSE perhaps took too narrow a view of its responsibilities in such incidents. At times, it was possibly more by fortune than anything else that loss of life did not occur. His impression was that the main criterion for causing an enquiry to be held was that there had been loss of life. He expressed concern about that situation. He felt that response to the consultation document provided one means for remedying the situation.

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49th ANNUAL CONFERENCE
18 - 21 OCTOBER 1982
LLANDUDNO

PART TWO
Report of Discussions

NATIONAL SOCIETY FOR CLEAN AIR
136 NORTH STREET
BRIGHTON BN1 1RG
ENGLAND

49th Annual Clean Air Conference
Llandudno, 18-21 October 1982
PART 2 - REPORT OF DISCUSSIONS

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EDITOR'S NOTE: Reportage of the Proceedings at the Conference has been curtailed by a technician's recording error which made it impossible to transcribe the tapes of Session 2, the second half of Session 3, and a small part at the beginning of Session 4, part I. What is published as an account of those sessions, therefore, has been derived from written contributions sent in by speakers who had retained notes of their comments, or who could recall the essence of their remarks. The authors kindly responded to this record, although obviously their replies are abbreviated since there was no verbatim transcript to consult.

Contributions from the following speakers are, unfortunately, missing.

SESSION 2

Naomi E.S. McIntosh, Chairman of Session (President of the Society)

Mr. L.V. Penzer (National Coal Board)

Mr. D. Bird (NSCA, Yorkshire & Humberside Division)

Mr. M.J. Gittins (Leeds City Council)

Mr. R.J. Kidd (Newtownabbey Borough Council)

SESSION 3

Mr. F.J. Feeley (Glasgow City Council)

Mr. E.W. Foskett (Manchester City Council)

Mr. J.E. Hall (Peterborough City Council).

SESSION 4, Part I

Mr. J.F. Barraclough (Author) (reply to Mr. D. Clark)

We apologise to our readers, and particularly to the above-named, for the loss of these contributions from the record. We should like to thank all the delegates who sent written versions of their comments. Their efforts, and above all, those of the invited speakers at the affected sessions, are deeply appreciated.
The Canolfan Aberconwy Centre management has expressed sincere regret for the technical mistake made with the recording.

KEYNOTE ADDRESS - COAL AND THE ENVIRONMENT

Lord Flowers, FRS

It is a great pleasure for me once again to address the National Society for Clean Air. You have a long history of trying to establish a sensible balance between industrial activity and environmental protection, but in spite of the enormous improvements in air quality which have been achieved in recent decades there remains much for you to do. Your influence is likely to be crucial if, as many expect, there takes place in the next decade a substantial increase in coal burn by urban industry. This is the subject of your first three sessions at this annual conference, and I am grateful for the opportunity to try to start you off.

I shall leave it to others to deal with your particular preoccupations. This evening I want to talk about more general issues facing the coal industry in its relationship with the environment, and in particular some of the major findings of the Report of the Commission on Energy and the Environment. Some of what I have to say may have a hollow ring given the attitudes of the present leadership of the National Union of Mineworkers.

The Commission on Energy and the Environment was appointed by the Government in March 1978 with the very broad terms of reference "To advise on the interaction between energy policy and the environment". Our task as we saw it was to try to establish a consensus about how to formulate energy policies in such a way that they might prove broadly acceptable amongst all the many interests involved. We set our sights at and around the end of the century, but did not forget the present or the past. We believe that the first requirement was to ensure as far as possible that the facts and the relevant arguments were known to all. Our Report is therefore, in part, an educational document - expository, descriptive and explanatory - paying as much attention to energy policy as to environmental implications. That, and the wide range of issues we tackled, account for the length of the Report - and for its cost.

We chose to study coal for fairly obvious reasons. Over the past 10 years nuclear power has been, and still is being, exhaustively studied in all its aspects. Whatever future one sees for nuclear power, and however optimistic one may be about energy conservation and the introduction of renewable sources, and however long one believes the present oil glut will continue, coal has a lasting place in the British energy scene with an annual consumption between now and the end of the century somewhere in the range 110 to 170 million tons, according to our best estimates, of which we assumed that most could and would be supplied by the National Coal Board, allowing for marginal imports and exports.

We addressed ourselves to those who were dubious about the future of the British coal industry, and not without reason for it could easily price itself out of the market. "The interest of the taxpayer and the energy consumer on the one hand," we said, "and the long-term prospects for employment and real wages in the mining industry on the other, can only be reconciled by investment in industrial modernisation and realistic wage settlements which allow coal costs to retain and increase their competitive edge over other forms of fuel. These two sets of interests," we continued, "cannot be reconciled by policies which lead the NCB to produce the last possible tonne from obsolescent, high-cost capacity - the burden which such a policy would place on the consumer or on the taxpayer could not in practice be endured - and to persist in such a course would certainly mean that investment in modernisation would be the casualty."

We found, broadly speaking, that there was no necessary conflict between these economic considerations and environmental requirements because, as we wrote, "This process of modernisation affords the best prospect of striking an acceptable balance between energy and environmental interests. New low-cost, high productivity capacity can be designed to high environmental standards. The bringing on-stream of such capacity will facilitate the phasing-out of obsolescent capacity in areas whose decline is associated with the worst environmental legacy of the past."

The legacy of the past gave us cause for great concern, because it is responsible for the image of the coal industry that most people have. A modern, well-planned, sensitively managed colliery need be no more in its environment than any other heavy engineering operation employing a few thousand workers. But it has not always been so, and as long as there remain great tracts of neglected and derelict town and country - in Yorkshire, for instance, and in South Wales - dominated by rusting pithead workings, by the bitter heritage of uncontrolled subsidence and scrofulous spoil heaps, people must be forgiven for believing, incorrectly to be sure, that this is what a flourishing coal industry exists to perpetuate and proliferate. Many of our recommendations were therefore concerned with clearing up the legacy of the past.

We were greatly impressed by what could be achieved nowadays with modern plant, with landscaped spoil tips, and with the rehabilitation of old workings. It encouraged us to believe that the adoption of current best practice throughout the industry, as at Selby for example, combined with the phasing out of obsolete plant, would prove to be environmentally as well as economically acceptable. There were, however, three areas where great care would be necessary - spoil disposal, subsidence and opencast mining.

The volume of spoil to be disposed of is immense. Spoil is produced in the UK at about 50 million tons per annum. At this rate it will require altogether about 5000 hectares of land by the end of the century in the form of 50 tips of 20 million tons each - an area, in aggregate, roughly equal to that of the town of Middlesborough. For the time being mining techniques and cost considerations mean that most of this spoil must be tipped locally. This sets a premium on improved tipping and restoration techniques, whereby the growing tips are progressively returned to environmentally acceptable, and if possible, productive form. We made a number of specific recommendations regarding tipping controls and landscape design but our chief concern was that - particularly in highly worked areas like West Yorkshire - there might not be enough suitable sites, and we noted that the problem of spoil disposal suffers from a lack of any coherent national or regional disposal policy.

We also acknowledged that with modern deep mining methods a measure of subsidence cannot be avoided. It can, however, to a much greater extent than was once the case, be predicted and its harmful effects minimized. Mines can be designed to avoid particularly vulnerable areas, and buildings can be designed to be flexible. Nevertheless, some small proportion of premises will continue to be damaged and our chief concern was with the system of compensation for the restitution of damage actually caused. We recommended that there should be improvements in the local operation of the subsidence compensation code, and some additional provision for residual loss in property values in the event of actual subsidence.It is important to recognise the fear that subsidence engenders amongst the affected public. "Although subsidence will be only one of the factors to be considered," we wrote, "it may in extreme cases rule coal mining out of the question or render the land above completely unsuitable for future use.

Local opinion will want to be satisfied that the effects will not be unduly deleterious if coal mining proposals are to gain public acceptance. It is thus in the nation's interest as well as the NCB's own interest to ensure that preventive and precautionary measures, and compensation, are planned and undertaken as effectively and as flexibly as possible, in order to reduce the stress and inconvenience for those directly concerned."

You will deduce from what I have said that despite detailed criticisms our Report was not at all condemnatory of the coal mining industry. We were impressed by much of what we saw and heard. That is also true of opencast mining, but there we came to rather different conclusions. We live in a densely populated land, one of sensitive landscapes in which opencast mining is peculiarly obtrusive and disturbing to farmlands and nearby homesteads. The difficulty is that the NCB makes up its losses on unprofitable deep mines by its profitable opencast operations. To be specific, in 1980/81 the NCB made a profit of £157 million on 15 million tons of opencast coal and a loss of £135 million on 110 million tons of deep mined coal. We thought that they should no longer seek to disguise this important fact. The losses on deep mined coal arise from unprofitable pits which we recommended should be phased out - as, indeed, they are being. As deep mining thereby becomes more efficient we recommended that the annual volume of opencast coal should be allowed to decline somewhat and should certainly not increase in the meantime. In the case of opencast operations we believed that the pendulum had swung too far against the environment. I emphasize that this was not our conclusion in respect of deep mining where we believed that environmental considerations had been well served in recent years.

Our Report, however, was not merely about coal production; it was also about the use of coal, including conversion to other fuels. We examined the market for coal, paying particular attention to the NCB's hope that there would be massive return from oil to coal in the industrial sector excluding power generation - the subject of your discussions tomorrow. A quadrupling of industrial burn from the present 10 million tons per annum was being anticipated, and we thought it important to examine this claim because of its obvious environmental, especially urban implications. As we said in our Report: "A recurring theme throughout our study has been the need for mechanisms which would translate the implications of national energy policy at the local and regional level. A striking feature of the evidence submitted to us is the general awareness of local authorities of the possible scale of re-entry of coal into the industrial market."

I am sure that this Conference will increase the general awareness of the problem.

The point is that the oil-coal substitution is not symmetrical. Storage and handling space for coal, once abandoned in favour of oil, is no longer available for a return to coal. Transport requirements are also different, and the boilers which have to be used. Fluidized beds seem particularly suitable for medium-sized industrial applications, but without government encouragement it seems that Britain's initial lead in this field could be eroded. We were satisfied that the required control technologies and powers exist in principle. What is mainly required is proper installation, maintenance and monitoring under supervision by trained staff. I will leave to others the development of this important theme during the Conference.

Of course, the main use of coal, certainly until the end of the century, will be in power stations. In 1980, 78% of the fuel used to generate electricity was coal; allowing for the decreasing use of oil, even if one is optimistic about the growth of nuclear power that proportion is unlikely to fall very much.

We made a number of recommendations regarding the transport, handling and storage of coal. Perhaps the most important was to urge the greater use of railways whenever that is environmentally preferable. In this respect we fully supported the Armitage Committee. Had we known of the difficulties now facing the railways we might have adopted a more desperate tone. As it was, our main concern was that investment in railway track and rolling stock should not become a bottleneck in the development of coal-fuelled power stations and the industrial use of coal.

We considered the conversion of coal to synthetic fuels, both liquid and gaseous. We concluded, at any rate for the UK, that commercial production of liquid fuels from coal was rather far off - well into the next century - and that synthetic natural gas would almost certainly come first - it is in any case likely to involve a simpler process. The existence of a gas network would obviously make its introduction that much easier. We thought it unlikely that SNG plants would introduce environmental problems that could not be tackled straighforwardly. A full-scale plant would be comparable in some ways to a 2000 MW coal-burning power station; in other ways it might resemble a petrochemical plant. In either case pollution can be contained. We did recommend, however, that before a full-scale commercial plant is engaged upon there should be satisfactory operational experience of a demonstration plant.

Much of our evidence and assessments concerned combustion technology and the residues of combustion which are the causes of pollution. In power stations smoke is no longer a problem because electrostatic separators work to an efficiency of 99.5% and the residual particulates are mostly dispersed as if they were a gas. Ash, although produced in great quantities - 2000 tons a day for a 2000 MW station - produces few difficulties except for the availability of nearby disposal sites. If fluidised beds are eventually developed for power station use to increase combustion efficiency and decrease sulphur emissions this would exacerbate the problems of ash disposal but not to such an extent that suitable sites could not be found.

The two emissions to air about whose effects there is continued uncertainty and concern are carbon dioxide and sulphur dioxide. Carbon dioxide is the inescapable end-product of the burning of fossil fuels. It goes directly into the atmosphere, from which about half is removed through the biocycle and exchange with the oceans. It is believed that the atmospheric concentration over the next 100 years will be double what it was in pre-industrial times, but other reasons for an increase are the massive deforestation that has been taking place in many parts of the world. Clearly it is a global problem to which global solutions will have to be found if and when anything has to be done. The possible effects of a build-up of carbon dioxide have been well publicized - principally a gradual warming of the atmosphere and a slow melting of the ice-caps, which could have long-term consequences for economic, agricultural and human settlement patterns. Not all these effects, be it noted, need be deleterious. Nevertheless, very distinguished and level-headed scientists have warned that "The carbon dioxide problem is one of the most important contemporary environmental problems which threatens the stability of all nations." As a result of these warnings there is now a comprehensive international research programme of measurement and of simulation under the World Meteorological Organisation. So far, however, no deterioration of climate due to carbon dioxide has been detected. The processes involved appear to be so slow that there is no justification for action at this time beyond continuing the research with due vigilance.

Sulphur dioxide is not so much of a health problem as it was once imagined to be, unless it is associated with smoke, and even then it is dangerous mostly to cigarette smokers who, quite literally, have the remedy in their own hands. The mandatory limits for smoke and sulphur dioxide set out in the EEC Air Quality Directive provide an adequate standard for the protection of human health. That being so, we also considered that they were adequate as regards local crops and vegetation and the protection of materials against corrosion.

There remains the vexed problem of acid rain. Sulphur dioxide, swept high into the atmosphere and carried across the North Sea, falls as acidified rain on to land which in certain parts of Scandinavia is already acid in character. There are signs of the same phenomenon in Western Scotland. Some of it also reaches the ground by dry deposition, but I will not go into that. The results are harmful to fish and to crops. How much of the damage results from acid rain and how much from the acidity already present is still hotly contested. It may be that adding lime to the appropriate watersheds would be a sufficient solution, although this too may have its side effects. The matter is being intensively research under a convention of the Economic Commission for Europe. If acid rain should turn out to be the major culprit - originating in parts of the Continent, such as the Ruhr, as well as in the United Kingdom - and if it has to be arrested at source, the solution is likely to be very expensive adding perhaps 10% to 20% to the cost of a unit of electricity. Someone has said that flue gas desulphurisation is the billion dollar solution to a million dollar problem. We did not think that enough was yet known to justify such expenditure at present, although we hedged our bets by saying that desulphurisation research should certainly continue.

Finally, we devoted a chapter to the planning process whereby, under the Town and Country planning system, one tries to reach an accommodation between the principle interests involved in any major development. The concepts of balance and of the interaction between energy policy and the environment were fundamental to our remit and to the way we approached our task from beginning to end. How that balance is perceived is a matter of opinion - the opinion of ordinary people as well as of experts. Ordinary people are no longer content that Ministers and their advisers have a monopoly of judgement of the public good. They want to participate in the decision-making process, and the means by which they do so, under the law, is the town and country planning system.

We therefore made a number of proposals for streamlining that system. I will not go into detail; suffice it to say that we assumed the public would have to be better informed of likely developments than they generally are at the present, starting from the top. It is first of all necessary that the Government should itself make clear at regular intervals how it views the energy scene - what are the requirements and how might they be met.

It is, of course, a scene that changes with time: with the state of the economy, with external events, with technological innovations, and so on. This, we believed, could nevertheless be made generally comprehensible and would greatly ease the problems of getting any particular development or project into proper public perspective.

Secondly, we though it important to have some idea of site availability - whether for a power station, a colliery, a spoil heap, or an SNG plant - well ahead of time, so that there can be an element of choice. It really is not good enough to research only one site and then to claim too late that there is no alternative.

Thirdly,we thought that consultation with local interests should be progressive, beginning early at an exploratory level, becoming gradually more comprehensive as and when the project moves forward. Many of the tensions which are encountered at public local inquiries, often the culmination of the planning process, would be eased by more effective dialogue between the relevant interests during the early preparatory stages of planning. The British town and country planning system is astonishingly versatile when properly used - hence, incidentally, much of the objection to the formal continental and American processes of environmental impact assessment.

I must bring this recital to an end, conscious that it has been patchy and that many important issues dealt with fully in the Report have gone without mention. (Perhaps more will come out tomorrow.) I must, however, express my grateful thanks to my fellow members of the Commission including your President, Naomi McIntosh. They all worked very hard during the 3 years of the study, doing their own thing very effectively, but coming together as a team whenever we had to reach a conclusion. They were fun to work with, and the spread of expert interest amongst them was such that in many respects we collectively resembled the wider public. We also had a devoted and highly skilled Secretariat. It would be invidious to mention names. Above all I have to thank our witnesses, many of whom took immense trouble with their evidence, both written and oral. It was evident to us from the beginning that we would have to work very closely with the NCB and the CEGB. Their efforts on our behalf - on their own as well, of course - were Herculean. But I want to assure you - and Dr. Gibson will confirm it tomorrow - that we distanced ourselves from them, checked up behind their backs, and reached our conclusions entirely independently.

Otherwise it probably would not have been the case that we made about 70 recommendations, mostly about how we thought they could and should do a better job. Many of those recommendations have already been put into effect; others are being intensively studied by the Boards, by local authorities and by the Government.

Let me end, then, by reading to you what is essentially the final paragraph of our Report which sums it all up as well as I can.

"Challenge and opportunity confronts the industry.

A modernised industry designed to high environmental standards can make an immense contribution to an energy strategy designed to diminish in longer term the dependence of the UK economy on imported oil. The decisive determinant of achieving the required restructuring of the industry will be investment in modernisation. Only by such investment will the industry be able to grasp the opportunities afforded by the evolving energy scene. If the interests of the taxpayer, the energy consumer and the industry's workforce are to be reconciled, an integral part of modernisation must be the phasing out of heavily loss-making obsolescent capacity. This calls not only for help to individuals but for a far greater degree than hitherto of forward regional planning in anticipation of the effects of closures on mining communities. It also requires the full co-operation of both sides of the industry in the operation of its existing machinery, the local authorities, bodies such as the Welsh and Scottish Development Agencies and central Government. Failure to face this challenge would be to tether the UK to the industry's past, to postpone into the next century the clearing up of the legacy of past dereliction, and to deny to the country the immense contribution which a modernised coal industry can make in supplying the country's energy needs without unacceptable environmental costs."

PUBLIC EDUCATION IN NOISE

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Large numbers of people are adversely affected by noise. The Organisation for Economic Cooperation and Development (OECD) estimate that 100 million people (15% of total population) in its 24 member states are exposed to noise levels greater than 65dB(A) L_{eq}. Relationships between noise levels and annoyance suggest that, as a result of these levels, at least 16 million people in the OECD countries will be highly annoyed by the noise climate to which they are exposed. In the UK alone the population exposed to levels greater than 65dB(A) L_{eq} is expected to rise from 11% (approximately 6 million) in 1980 to 17-20% (9-11 million) by 2000. Additionally, noise may be dangerous to health and hearing. Also in the UK some 2.6 million workers in manufacturing industries (excluding mining, construction and agricultural activities) are subject to levels which are likely to lead to disability in hearing for a proportion of that population. These risks are extended into recreational activities such as attendance at discotheques and pop concerts and other high noise level sports such as rifle or pistol shooting. Collectively these effects cover the whole range of noise levels experienced by the population. Fig 1 shows the range of effects against the noise level.

There is a tendency to believe that only high noise levels cause problems whereas, can be seen from Fig 1, people are affected by noise over the whole range. Even at the very lowest levels many Environmental Health Officers (EHOs) will be aware that complaints are received e.g. about noise levels in the 20-30dB(A) range, particularly in rural areas or even in some urban areas at night time. At the upper end of the scale there is an increasing possibility of death, since like any other form of energy, noise is capable of causing serious and irreparable damage to human tissue. Fortunately, as the diagram shows, normal sound levels are well below this but between extremes a wide range of effects may be experienced.

These effects can be categorised into 3 areas:

Category	effect
Nuisance	annoyance disturbance interference complaints
Intermediate	performance efficiency
Biological	Hearing loss - temporary - permanent skin and endocrine system changes respiratory effects organ resonance death

For the present purpose we might divide effects in two: nuisance, and health effects.

NUISANCE

What is clear over the past twenty years is that there has been a growing awareness of noise as a pollutant as measured by community reaction. Complaints, as a measure of community reaction, have continued to increase over the past decade against all sources of noise. The Institution of Environmental Health Officers (IEHO) reports complaints received by local authority Environmental Health Departments. These figures, which are shown in Fig 2, only cover actionable sources under the Control of Pollution Act 1974 and exclude complaints against street chimes, traffic and aircraft but demonstrate convincingly the level of public concern. Moreover, complaints only relate to the 'tip of the iceberg' as one has, it can be assumed, to be highly motivated to complain. A particular feature of the trend in complaints has been a significant increase in complaints against domestic sources, of which Hi-Fi, TV, DIY and lawn mowers etc. form major contributions.

These figures emphasise not only increasing concern and awareness but, more particularly, a lack of understanding: an understanding that, because by definition noise is unwanted sound, we are all at some time in our daily lives transmitters as well as receivers of noise. Each time we drive our car or turn up the volume of control of our hi-fi system we invariably produce sound which is objectionable to someone. This is clearly a reflection of the attitudes abroad in society today on some aspects of our behaviour toward others.

HEALTH EFFECTS

As noise levels increase the possibility of physiological damage also increases. Nevertheless, within this range there are also possible beneficial effects. Workers have to work if goods are to be produced. Young people enjoy loud music and people enjoy motor sports and rifle shooting. Unfortunately, or fortunately depending on how you view the problem, most of the effects are long term, and hence, unlike many other forms of pollution, do not cause immediate and widespread public concern. Moreover, many of these effects involve complex technical and statistical issues which confuse the layman, and some are still in the early stages of research. Yet enough is known to indicate the need for caution in exposure to high levels of noise and to warrant concern about the apparent lack of understanding, or in some cases even awareness, in many sections of society.

All our efforts to date on the problem of nuisance and health effects have been directed towards control through statutory powers. The majority of these powers are concerned with nuisance effects and yet we see from the figures that even after two decades of statutory control (the first Noise Abatement Act was introduced in 1960) complaints against such effects continue to rise. Statutory powers to control health effects are directed primarily towards industry where the problem is greatest. In both cases attention has been drawn to the problem by the need to avoid falling foul of the law but there is little understanding of the related issues. Outside the areas of statutory control, particularly in the field of leisure pursuits, there is not only a lack of understanding of the problem but also a lack of awareness that the problem exists. What should, I hope, be clear in my paper to date is that our current policies on noise control are only serving to create an awareness of the problem without promoting the necessary understanding which might result in changes in behaviour. I should hasten to add that the statutory powers in themselves are not failures, far from it, but they serve as the 'STICK' rather than the 'CARROT' in influencing changes in attitudes and beliefs. Moreover, they are rightly designed to deal with the most common and severe problems, thus leaving many problems untouched and less severe problems ignored. Indeed, it may be argued that statutory powers, particularly where limits are specified, if not encouraging then at least permit noise which might otherwise be avoided as there is an implicit assumption that levels lower than the statutory requirement are not a nuisance or harmful. What is clearly demonstrated by the whole range of noise problems is the need for a concerted programme of 'Public Education in Noise'.

EDUCATION

If you ask the man in the street what he understands by 'Education' the majority would, I suspect, say that it was about 'learning'. Whilst true, education goes far beyond that. It is about the shaping of attitudes and beliefs which influence behaviour. Clearly, then, if we can educate the public in noise matters we should be able to influence behaviour and hence contain, if not reduce, noise. Many will consider that this is purely wishful thinking. Currently, and when referring to noise in general, this may be so, although in the long term this also ought to be possible. What can and ought to be done in the short term is to tackle specific issues such as noisy neighbours or hearing damage risk from leisure pursuits.

In order to do this we must design a suitable education programme. Most people associate such programmes with publicity and the media but good education programmes are much wider than this. They contain Clear Objectives which identify the target group, the particular area to be included and a Strategy by which objectives might be achieved. Before the programme can be devised the Attitudes and Beliefs of the target group must be determined in order to devise the best line of approach. The programme must set out to Inform and Promote, firstly to raise the level of awareness and then to improve understanding. It is then important to Persuade and Motivate people into changing their behaviour. And finally, it is necessary to Evaluate the Results so that improvements can be incorporated in successive programmes. It is rare to find all these aspects in a single programme and many so-called educational programmes concentrate on one or two elements alone. The reason is not far to seek. Complete programmes are expensive and time consuming and in some cases it may be better to make some reasonable assumptions, particularly about attitudes and beliefs, in order to proceed. For example, if we decide to initiate a national programme related to the risk of hearing damage from using headphones, our target group is clearly defined - manufacturers, retailers and users. We can assume that very few of our group will be aware of the problem and that attitudes amongst users will be that 'it must be OK because the manufacturers haven't said that it isn't', 'I play it loud because that's the way I enjoy it', 'any after effects I have disappear in a couple of hours so I don't think there's a problem', 'it's interfering with my personal liberty' etc. In order to proceed we might then start to inform and promote the problem by publicity via manufacturers, the media, user groups and clubs etc. Persuasion and motivation may have to wait as this is best done in small groups which is clearly difficult on such a scale. The same might also be said of any attempt at evaluating the results. However, try the same exercise at local community or group level and it should be possible, and highly desirable, to invoke all the elements of the programme.

Clearly, educational programmes on noise can be organised on either a national or local basis. For the promotion of national programmes central government ought to be the motivating force as successful programmes might reduce public expenditure. Currently, the Government relies on individual Departments to set their own policies and priorities. This involves a wide range of areas where noise may or may not be important. No central priority or policy forming body exists to give advice. A major setback in this respect was the axing of the Noise Advisory Council (NAC). This was the only body to date in the UK to sponsor a full educational programme in the form of the Darlington Quiet Town Experiment. This exercise involved all the elements of a good programme previously mentioned. While the results were inconclusive, primarily because it was attempted on too wide a front with inadequate resources, it was a step in the right direction and many useful lessons were learned. The NAC also produced many other useful reports but its major contribution was that it acted as a talking shop for all the interested parties and maintained a broad interest over the whole range of noise problems in order to set priorities. One such priority was to improve public education in noise matters.

The Government could, if it wished, direct some of its other agencies to promote programmes; for example, the Health Education Council clearly ought to have a role to play. It might also sponsor research into small scale specific programmes which might be more rigorously applied and evaluated and encourage, by suitable grants, LA's to promote topic-specific programmes on a small scale. Government policy will in future be influenced by the EEC which has taken on board a commitment to reduce noise effects in the member states. One aspect of this will be to introduce noise labelling of products which is,no doubt, a useful exercise in the promotion of awareness of noise problems. The EEC is further committed to rationalising legislation on Noise Induced Hearing Loss in industry, and the proposed (UK) Health and Safety at Work etc. Act regulations on the subject recently circulated for comment might be delayed until the EEC decision is made known.

ROLE OF THE PROFESSIONS

Professional bodies have an important role to play in 'Public Education in Noise'. Their first duty is to ensure that their own members have the requisite skills and knowledge to design noise out of products and services. It is only recently that some professions have included 'noise' in their education syllabuses. Often this is directed more towards academic principles rather than practical effects on people and there is a need for some change in many instances. Professions which are particularly important are Planners, Architects, Builders, Mechanical and Production Engineers, Audio Engineers etc. Their contribution is to see that the public's interests are served by

1. Keeping abreast of modern technology.
2. Including 'noise' as one of the major design criteria for products and services.
3. Informing the public of noise hazards associated with their products.

One professional, the Environmental Health Officer, has a more central role to play. He occupies a unique position in his contact with both sides of the problem: the transmitters and receivers. He is in a position to offer both the 'carrot' and the 'stick' (Education or Enforcement). Currently and all too often the 'stick' is used because it is expedient to do so because of pressures on manpower etc, but in many cases the EHO is involved in 'one to one' or 'small group' situations with clear educational possibilities. Such opportunities are often lost because of poor communication skills and/or lack of a departmental programme or policy to cover such circumstances. The EHO must prepare himself for such opportunities by acquiring the necessary communication skills and ability to plan programmes. And, because of his central role in noise education and many educational possibilities in other fields of his work, this acquisition of education skills ought to form part of his basic professional education.

INDUSTRY, COMMERCE AND UNIONS

Many sections of trade and industry are run by professionals. In such circumstances it might be expected that their professional education in noise ought to feed into their products and services. However, market forces may dictate otherwise. There is, therefore, a role for the related Trade Organisations (from the CBI downwards) to 'educate' its members. In turn, where a company's products or services are seen to affect the public they should either be suitably modified or their customers informed of the effect(s).
Particular areas where such education would be useful are:-
Factories and environmental noise, noise and workers, safe use of products e.g. headphones, safe operation of services e.g. discos. By far the most active on this front is the TUC and the Trade Unions, which regularly organise programmes for union representatives and produce useful information on the subject of Hearing Damage in Industry for their members.

Other areas in which progress might be made are:-
Youth groups, leisure organisations, hobby clubs where members can be informed and educated to undertake their activities safely and without disturbance to others.

By far the most effective, but long term, programme would be implemented through the school curriculum where the formative mind of the child can be reached before attitudes become too firmly entrenched. Such a programme ought to be encouraged by the government through the Department of Education and Science, the Schools Council, local authorities and teachers' organisations. The place to start would be in the Teacher Training Colleges so that teachers are aware of the problem. Much of the teaching can be done via science-based project work with simple inexpensive equipment. Some countries have already made a start: in the Netherlands and USA school project work has been introduced in some areas. At local level the EHO might again play a role in 'educating' teachers and pupils on noise problems.

CONCLUSIONS

In the time available I have only been able to explore the broad outline of the opportunities for Public Education in Noise. Much of the fine detail needs to be developed further. I have tried to examine the strategy for educational programmes and hopefully point the way for their application. If such programmes are to succeed they will require support from central and local government, the professions, industry and commerce; and the EHO is seen as a central character in the design and implementation of many such projects. It would be wrong to believe, or even imply, that education will provide the solution to all our noise problems. There will always be a role for statutory powers and physical noise control techniques, but education ought to be considered as a serious strategy in the fight against excessive noise. In the short term, educational programmes may achieve best results in specific areas such as domestic noise and health effects. In the long term, progress will only be made by creating a generation of noise conscious individuals through the general educational system.

As indicated earlier, papers like this only inform, but if I have made you aware of the possibilities and opportunities and hopefully motivated you towards exploring for yourselves some of the avenues open to education then my objective in presenting this paper has been achieved.

TUESDAY 19 OCTOBER

MORNING
SESSION TWO

TRANSITION TO COAL IN INDUSTRY

P.T. Reynolds, Director, Shell Boiler Division, Babcock Power Ltd.

TECHNICAL DEVELOPMENTS IN INDUSTRIAL COAL UTILISATION

Dr. J. Gibson, NCB Coal Research Establishment

MR. R.W. LANDER (Middlesbrough B.C.) opening the discussion, took the opportunity to thank both speakers for their excellent papers; Mr. Reynolds had outlined in his paper the transition to coal in industry whilst Dr. Gibson had outlined the technical developments in industrial coal utilisation.

Mr. Lander said that those who had at heart the objective of achieving a clean and healthy environment in which to live and bring up children could reflect that it was just 30 years since the tragedy that had caused the Government to set up the Beaver Committee, which had resulted in the introduction of the Clean Air Act, 1956. At that time, most of the problems had stemmed from low level smoke and SO_2 emissions from domestic chimneys, although industry had also had to shoulder its fair share of the blame.

Over the past 30 years most local authorities had progressively introduced smoke control orders which had served to reduce dramatically the average ground level concentrations of smoke and SO_2, to what in many cases might safely be regarded as natural background levels. (In Middlesbrough, the levels had been reduced from 600 $\mu g/m^3$ smoke and 350 $\mu g/m^3$ SO_2, to something like 20 $\mu g/m^3$ and 15 $\mu g/m^3$ respectively over that period.)

In addition, EHOs and the Alkali Inspectorate had used available legislation to control the activities of industrialists in order to effect environmental improvements; the phrase "control the activities of industrialists" was used advisedly because more often than not any contravention of the legislation had resulted from the acts or omissions of people rather than defective or inefficient plant.

Mr. Reynolds had stated in his paper that: "most energy conversion plants would have a life of 15 to 20 years." Therefore, it was clear that since the introduction of the Clean Air Act, 1956 most, if not all, boiler plant would have been renewed, and ought to have received the necessary approvals as to their capability of burning fuel substantially smokelessly; the grit emissions would have been controlled within reasonable limits and the products of combustion discharged through chimneys of a height to ensure the minimum acceptable ground level concentrations of polluting gases.

Mr. Lander was certain that all the delegates present would view with concern the extent (or rather, the lack of it) of the present extractable world resources of oil, gas and coal. During the previous 30 years, many coal fired furnaces had been converted or replaced with plant that would burn oil or gas. That change had entailed many advantages, such as storage facilities either reduced in size or dispensed with altogether, automated plant that would comply with clean air legislation and yet required little or no manpower.
Mr. Lander recalled the Society's Immediate Past President, Sir Derek Ezra, extolling the virtues of coal at a previous Clean Air Conference, explaining that, because of the vast reserves, coal was to be the country's saviour and the fuel of the future.

However, those who lived on the coalfields of the country knew only too well the problems created in the environment from deep mining and opencast operations. Many a scar of the past was but now being restored to its former beauty; Mr. Lander expressed the hope that the NCB and others would have learned a lesson from the past and would ensure minimum detrimental effects to the environment when extracting coal for the future.
Coining a phrase, Mr. Lander hoped that they would Beaver away a little more carefully in the future, noting the number of ways 'Beaver' could be spelt in

the context!

Mr. Reynolds had referred to the £50 million worth of grants that the Department of Industry had made available to encourage industrialists to renew gas and oil fired plant to coal fired installations.

He had recognised that there had to be a fuel cost benefit of about 10p per therm in favour of coal firing for conversion to become economically viable and had suggested that only larger installations would move to coal firing.

The most telling sections in Mr. Reynolds' paper had been those dealing with the selection of boiler plant, and grit arrestment plant. He had referred to the usage to which plant was required to conform: (a) the range of load; (b) the response to load changes; (c) operational steam pressure, and finally (d) local environmental requirements. Mr. Lander thought that the industrialist would be more concerned with the first three, whereas those at the conference were, or ought to be, more concerned with the last. Mr. Reynolds had divided grit arrestment plant into five categories: (a) settling chambers; (b) mechanical collectors or grit arrestors; (c) bag filters; (d) washers or scrubbers, and finally (e) electrostatic precipitators.

Mr. Lander pointed out that they were listed in ascending order of capital cost. He said that it would come as no surprise that the go/no go line probably fell between bag filters and washers or scrubbers, and that electrostatic precipitators were out of reach of most small to medium-sized installations burning coal other than PF - although Mr. Reynolds had voiced his reservations in that connection. Most probably the combination would be between settlement chambers and mechanical collectors. Dr. Gibson had described the technological advancement made in coal handling, storage, firing and combustion processes, and in particular the development of FBC. He had explained how SO_2 and NO_x emissions could be limited with fluidised bed combustion systems.

In short, the two speakers had made it clear that the technology existed to rebuild the coal burning industry and to protect the environment at a cost, which led him to the sentiments expressed by the President (Naomi McIntosh) the previous year, referred to again that day by Mr. Reynolds.

It was at that point that industrialists and environmentalists became at odds with one another. The industrialist, on the one hand, was bound to consider a cost-benefit analysis in relation to his business, whilst the environmentalist was concerned with the cost-benefit analysis as it related to the protection of the environment in terms either of seeking improvements or of simply protecting that which had been achieved.

In Mr. Lander's opinion, two things were required. First, the NSCA ought to consider how best to strengthen existing legislation so as to provide adequate safeguards for the protection of the environment from the possible soft option approach that might be adopted by an irresponsible industrialist availing himself of coal as a cheaper fuel; secondly, he believed that local authorities ought to be taking advantage of the considerable assets they had paid for over many years in introducing smoke control orders. His own Council had adopted a new system of Air Quality Management. Briefly, Middlesbrough used a mathematical box model to assist in the prediction of ground level concentrations, and by using the EC Directive specified "Guide Values" as absolute ceiling levels, were able to plan for industrial growth and the creation of much-needed employment. He noted that Dr. Williams of Warren Spring Laboratory would be discussing the method in detail later in the day.

In conclusion, Mr. Lander asked the speakers whether they honestly believed that industrialists and the NCB would have sufficient regard for the environment, bearing in mind the track record to date, and, more particularly, the acute financial situation which many institutions found themselves constrained by. He asked whether Dr. Gibson and Mr. Reynolds would agree that the time had come to consider strengthening existing legislation so as to protect the environment from the improper combustion of coal by industry.

MR. I.W. BARKER (Sheffield City Council) expressed disappointment that the technical developments referred to by two speakers seemed to be no more than modifications of technology which was already 50 years old. He had hoped that, in the light of the limitless future which coal could look forward to as the nation's prime energy source, consideration would be given to the development of new technology more in keeping with the advances of the 20th Century now nearing its close, and the challenges of the 21st Century only 18 years away.

Mr. Barker referred to his training and his attendance 25 years previously at a Royal Society of Health Smoke Inspectors Course. There he had learned about shell boilers and reciprocal grates and sprinkler stokers whiich had then been in use. 25 years later a session of Conference devoted the latest technical developments still featured shell boilers, reciprocal grates and sprinkler stokers. If military technology had progressed at the same rate as coal combustion technology then the South Atlantic armada would still be in passage and if and when it ever reached its destination the Falklands conflict would have been resolved by a short encounter fought with flint axes.

Mr. Barker stated his belief that the concept of burning raw coal in a grate was outmoded. If it was not possible to develop the means of realising the full bounty of the priceless resource of coal in a manner which did not entail significant environmental disbenefits, then future generations would regard us as having failed them.

CLLR J.R.P. EVANS (Rhmney Valley B.C.) said that Dr. Gibson had appeared to suggest that recent technological developments in the incineration of raw coal would obviate the need for Solid Smokeless Fuel like that produced - with considerable and detrimental environmental impact - at the Abercwmboi Phurnacite Plant in the Cynon Valley.

He commented, as an aside, that the slide displayed had not been truly historical; conditions were still the same.

That proposal or suggestion would, if implemented, have a further serious impact on the area in employment terms, both for the plant itself and for the collieries in the South Wales Coalfield supplying their product to the plant. Unemployment was already high in the South Wales Valleys because of the Government's policies; implementation of the proposal would be disastrous.

Cllr. Evans explained that he was not suggesting unchecked production of smokeless fuel for the preservation of clean air in Manchester, Leeds or London at the enormous cost being borne in terms of environmental nuisance by the people of the Cynon Valley. At all times environmental considerations had to be balanced - it was, after all, 1982 not 1882.

He asked Dr. Gibson whether it was the intention of the Board (N.C.B.) to increase the incineration of raw coal in Smoke Control Areas, to be able to run down obsolete plant, like that at Abercwmboi, thus relieving the Board from having to recognise its responsibilities, long overdue, in investing the finance to replace the plant with a modern pollution free plant in the Cynon Valley.

MR. W.F. SNOW (Warrington Borough Council) said that in considering transfer from oil and gas firing to coal firing it would be necessary to take into account the increased labour costs that coal firing demanded. It was a more difficult fuel to burn efficiently and more operators would be required with specialist skills in adjustment of plant and ancillary equipment. Coal boilers also required more frequent cleaning which added to the maintenance costs.

The burning of coal would require more extensive pollution control equipment and alarms to be fitted to the plant; that would similarly need to be taken into account in considering the costs of conversion from oil or gas.

His final point related to the problems of increased noise levels which were certain to arise from the handling of coal and ash at converted plants, especially where those were situated in close proximity to dwellings. People today were much more sensitive to the impact of noise on their environment and were not so tolerant as they had been in years gone by when coal had been in regular use at commercial and industrial establishments.

MR. J.F. BROWN (Approved Coal Merchants Scheme) said that there had been mention of coal burning room heaters approved for use in smoke control areas. He asked whether any similar central heating boilers would be coming onto the market. DR. GIBSON said that some were under development, but he did not know when they would be marketed.

DR. J. GIBSON, replying to points made during the discussion, said in response to Mr. Lander that the National Coal Board's objectives included providing the best possible service to its customers by means of advice and technical solutions to customers problems, where necessary. Protecting the environmental was an important part of the service. The Commission on Energy and the Environment had concluded "We consider that industrial coal burn can be positively encouraged in most circumstances". They had made some useful recommendations for dealing with the exceptional cases and he considered that they would not require drastic legislation.

Dr. Gibson was unable to accept Mr. Barker's criticism that the technology was old. Combustion processes involved relatively simple reactions which had been known for a long time but the progress had been to improve the control and efficiency of coal burning. The past decade alone, had seen the introduction of pneumatic coal feeding and ash discharge, and microprocessor control to conventional combustion, while developments of new systems such as the smoke reducing domestic appliances, fluidised combustion with in-built

SOx emission control and so on were now available commercially.

Responding to Councillor Evans' points, Dr. Gibson said that considerable effort and money had been spent at the Phurnacite plant. It was an old plant, could not last indefinitely and the NCB was actively considering alternative processes which would satisfy the authorities environmentally. It was the Board's policy to continue to provide smokeless fuel. It had also developed appliances to burn coal and meet the Clean Air requirements.

He commented that the means to overcome the difficulties that had been mentioned by Mr. Snow were largely available now. The price advantage of coal compared with the other fossil fuels enabled the costs of providing automatic feed, combustion control and ash discharge systems to be borne. There were also benefits of noise reduction from these systems which could be automated to a fairly high degree.

MR. P.T. REYNOLDS responded first to Mr. Barker's concern that most coal combustion technology was at least 25 years old and had not kept pace with the micro chip era. Mr. Reynolds said that he was equally concerned that combustion equipment had not matched the electronic revolution but the fact remained that coal technology had, in the time to which Mr. Barker referred, been replaced by oil and gas firing.

The micro chip age could only be referred to in the control of combustion equipment and not the equipment itself. The only real advances in the burning of coal had been in fluidised bed combustion.

Mr. Snow had posed a question relative to the differential in price of 10p per therm between oil and coal firing, and Mr. Reynolds' statement that if that differential was maintained, coal firing equipment would be viable. He had also asked if consideration to extra maintenance was required for coal firing equipment. Mr. Reynolds replied that the 10p took into account the probable increased maintenance of coal fired plant which could be said to approximate to 3p per therm; that had been taken into account in his paper.

Mr. Snow had also raised the point of noise levels in the handling of coal. Mr. Reynolds replied that the handling of smalls would have very little effect on noise levels in the plant.

Mr. Brown had asked whether fluidised bed was a viable proposition on the domestic market. Neither Dr. Gibson nor Mr. Reynolds saw fluidised bed firing as having a worthwhile role to play in the domestic market. Fluidised bed firing was associated with the medium sized industrial plant.

One member of the audience had queried the use of smokeless fuels on shell boilers. Mr. Reynolds replied that none of his company's shell boiler installations burned smokeless fuel and he could not foresee any consideration being given to it as a viable proposition for the future.

TUESDAY 19 OCTOBER

AFTERNOON
SESSION THREE

USE OF SOLID FUELS - DISCUSSION PANEL

C. Kibbler, Managing Director, Rexco Ltd.
R. Pane, Marketing Director, Coalite Group PLC
R. Payne, Head of Applied Development Branch, NCB Coal Research Establishment
M.J. Sambrook, Marketing Director, National Smokeless Fuels

MARTHA BREJCHA (Munich University) opened the session with a question on the process of manufacturing solid smokeless fuels, asking also what environmental damage might be connected with that process.

MR. C. KIBBLER (Rexco Ltd), replying to the first part of the question, on the processing of bituminous coal for the removal of the tars, the oils (in fact, all the smoke producing elements seen earlier on the audio visual presentation) said that these were distilled from the coal by either a high- or low-temperature process leaving a carbon-enriched product which would burn with a flame, some with more flames than others depending upon the temperature of the process. Obviously, the tars and the oils having been taken out, they were not then present in the atmosphere to form the smoke, which in turn under the right conditions would form smog. In addition of course, there were the naturally smokeless fuels such as anthracite and dry steam coal, both of which were mined.

On the second part of the question, Mr. Kibbler said that it would be wrong for smokeless fuel producers to pollute the atmosphere around their plants. However, it was not the easiest job to prevent pollution completely and a slide had been shown that morning of a plant near a town (Aberconwy) in Wales, where the pollution was pretty bad. Equally, Dr. Gibson had mentioned, and indeed shown a slide of, a modern plant where the pollution was virtually non-existent; that was the way that the manufacturers of smokeless fuels had moved in the last 10 years; that is, towards processes which produced less and less pollution within their own environment.

CLLR. L. HARRISON (Wakefield Metropolitan District Council) said that there were two types of solid fuel user in his area: first, the concessionaires (particularly retired miners) who had changed to smokeless fuel, and second, those living in smoke control areas who wanted to get smokeless fuel through the distribution network but were unable to do so. In inclement weather, such as had occurred in the winter of 1981/2, there could be delays in delivering concessionary fuel to old age pensioners, for example. As a local councillor, he was looked upon as the father of all things and the resolver of most, and this applied equally to the supply of smokeless fuel. However, he did not work for the Coal Board, and knew nothing about distribution arrangements in the Doncaster area; he simply felt that there was a bottleneck.

Those who wished to purchase solid smokeless fuel could not do so, even when at the plant two miles down the road there were 50,000 tonnes in stock, burners being shut down and men laid off because the fuel was not being sold. Purchasers had to travel miles to a distribution point to collect the fuel. Cllr. Harrison said that he had never been able to fathom the complexities of the problems faced by the distributors, but something seemed to him to be wrong, somewhere along the line, and it was a particularly aggravating problem for people in his area.

MR. R. PANE (Coalite Group plc) agreed that the problem referred to was one of distribution. Over the past three or four years, with the exception of a very specialised type of fuel, anthracite beans, there had been no shortage whatsoever of manufactured solid smokeless fuels.

As Cllr. Harrison had quite rightly said, there was an abundance of availability and plant capacity but there were occasionally problems so far as distribution was concerned - there was indeed such a problem in Yorkshire.

The manufacturers were quite prepared to produce whatever the market required and, when necessary, to carry stocks, bearing in mind that there always remained the possibility that in the winter the railways would have problems and roads might get snowed up, as they had the previous year, which could lead to problems in getting supplies to distributors.

What producers had been trying to do for years was to get the distributors to stock up at least a proportion of supplies in the summer; a large number of distributors already did so. Mr. Pane was himself connected with a large retail organisation in the south and at the present time nearly three months of stock were being carried on the ground to guard against winter contingencies. Therefore, if there were problems in Yorkshire or anywhere else, the supplies were available and it was up to the Trade to take them and put them down. The incentive, in the difference between winter and summer prices, was sufficient and adequate to cover the financial costs. There was no reason whatsoever why anyone in the country should not have an excellent service of manufactured solid smokeless fuels. The fuels were readily available, but in certain areas he considered that the Trade did not always carry the stocks that they should.

That then rebounded onto the producers who carried the stocks. However, in a cold snap such as had occurred the previous year, orders could leap from 10,000 tonnes to 30,000 tonnes overnight. Whilst producers had the ability to despatch they could find that the railways or lorries could not get into the works because of the weather conditions, which resulted in some weakness in distribution. The solution was for far greater stocks to be carried in the merchants'yards to meet such winter problems. In his opinion this was part of the service the Trade should give to consumers; those in the solid fuel industry could not afford to lose one customer. In the Yorkshire area, specifically, there had been some retail problems, which he believed had been overcome.

It would also be appreciated that when manufacturers were dispatching thousands of tonnes of fuel in hundreds of vehicles each day, it was not possible to supply the individual consumer. Manufacturers were geared to look after distributors, who were the key links with consumers. When there was a problem regarding supplies it was invariably due to the unwillingness of some distributor to stock enough in the summer; every merchant ought to carry 6/8 weeks'stock to help cover his winter requirements.

MR. D. BIRD (Yorkshire & Humberside Dicision, NSCA), commenting on the natural overlap with the next session, when Mr. I.W. Barker would be talking about some of the problems encountered in Sheffield, said that he did not want to steal any of Mr. Barker's thunder. However, there were a number of points that he thought relevant to address to the members of the Discussion Panel. The first one was the thorny question of price. As the audio visual presentation had shown, the claim was no longer made that it was cheaper, or as cheap, to burn smokeless fuel than to burn coal; the word "comparable" had been used. In Mr. Bird's view, it was not even particularly comparable; he had no doubt that in an average household, householders were wasting fuel, not burning it efficiently, and could not hope to achieve the efficiency claimed on the audio visual.

Mr. Bird said that there were two basic problems in selling smokeless fuel to the householders in Sheffield; the first was perceived costs. Every time that a percentage increase in price was imposed by the manufacturers, in line with the dictates of their suppliers, the NCB, the price differential between smokeless fuel and coal increased. All those in Local Government knew about percentage increases, particularly as they affected salaries, and the same thing applied to percentage increases in smokeless fuel. Mr. Bird said that the manufacturers really had to do something, in conjunction with the NCB, to keep the price of solid smokeless fuel down round the price of coal. He realised that that might upset the NCB because they would probably not be able to sell as much coal outside smoke control areas; however, he felt that it was time the NCB and the smokeless fuel suppliers, the private suppliers as well as NCB subsidiaries, got their act together on the business of pricing. The merchants could also help by educating the users not to waste fuel, promoting the most efficient use of fuel. Mr. Bird expressed his sincere belief that most coal merchants were unwilling or perhaps unable to educate their customers. It was an area in which work was required, because a large slice of the market was being lost to the other fuels, and it could all be laid at the doorstep of the merchants supplying the fuel.

That led Mr. Bird onto the question of prevention of sales of bituminous coal in smoke control areas. He believed that the scale of contravention was not recognised because local authorities did not have the resources to investigate the illegal sale and use of coal in smoke control areas. Every local authority had problems similar to Sheffield's if they looked for them but their staff had better things to do, as had been heard that morning. It was important to talk to the NCB and to discuss the future of pollution control - not to tell a little old lady she couldn't burn coal on her grate.

MR. M.J. SAMBROOK (National Smokeless Fuels Ltd) took up the last point first, because it was one with which he felt everyone on the panel would be in agreement. The panel were totally opposed to the illegal burning of coal in smokeless areas and indeed had a vested interest in the matter. However, it was very difficult to see what producers of solid smokeless fuel could do to stop it. Most of their plants and officers were far away from the smokeless zones themselves so they could not exercise direct supervision; the aspect of enforcement would be the topic of further discussion later in the afternoon's session.

On the question of price, Mr. Sambrook agreed that the producers would like to see smokeless fuels absolutely identical in price with coal. That would be a perfect situation from their point of view because the advantages of smokeless fuel were such that they would sell far more. The claim that had been made on the audio visual was a perfectly valid one; ton for ton, value for money in terms of useful heat was about the same. However, referring to Mr. Bird's plea for the Coal Board to come to an arrangement with solid smokeless fuel producers, to sell at identical prices, it had to be remembered that the producers started from the coal and processed it. In the course of processing it, considerable added costs were inevitably incurred and, moreover, the initial volume of coal could not be turned into the same volume of smokeless fuel. On some plants the yield might be as low as 50 to 60%; certainly 70% was a perfectly good average for the plants which were operated by NSF. Therefore, one ton of coal could not be turned into one ton of smokeless fuel at the same price. There were all the costs of processing to be considered, together with the loss of 30% or more of the initial material so there was bound to be a price gap. However, the Coal Board recognised that in their pricing of coal to the manufactured fuel producers, and made concessions which allowed for the fact that the producers would have to spend money in processing the fuel. The Coal Board were equally very concerned that the differential should not widen; like the manufactured fuel producers, the Board wanted to maintain the largest possible market for solid fuel. Percentage increases did, inevitably, cause widening of different base prices, but the movement in price in money terms, as distinct from percentage terms, of smokeless fuels compared with coal had been much closer in the past two years than it had been three or four years previously.

MR. C. KIBBLER wished to add a comment which directed the issue back to the local authorities, on the question of burning smokeless fuel wastefully. He knew that some, perhaps all, local authorities, issued a guidance leaflet to householders when an expensive appliance such as the room-heater was installed in local authority houses. That leaflet or booklet explained how to get the best out of the appliance. However, he wondered, and had discussed the matter with his colleagues on previous occasions, what happened when that house changed hands: i.e. was the new occupier issued with the leaflet or did local authorities hope that it had been left behind for the nextcomer. He considered that education was, and would continue to be, one of the most important means of reaching those who were not burning their smokeless fuel properly. He suggested that the task of education was one for the local authorities, as well as for the SSFF, SFAS and the producers.

MR. A.J. COLLETT (Nuneaton & Bedworth Borough Council) asked a brief question on the fixing of solid fuel appliances. It was essential for efficiency, and very important for the economy of the user, that they were fixed properly. Formerly, fixing had involved the use of asbestos string or rope for sealing purposes. He did not know whether it was still being used, but felt that in the light of present knowledge of the dangers of asbestos, local authorities would be extremely reluctant to advise the use of this material in the very necessary sealing process. He asked whether there was a suitable alternative.

MR. R. PAYNE (NCB, Coal Research Establishment) said that there were alternatives to the use of asbestos seals in appliances. Since the asbestos scare, a few years previously, CRE had tried to encourage manufacturers to look for and use alternative materials. Several alternative materials were available, the main one being the ceramic fibre seal. Another was a form of package glass fibre seal that unfortunately was only suitable for use below certain temperatures. The problem with the ceramic seal was, he thought, its price. It cost, or had originally cost, something like five or six times the equivalent asbestos seal. However, he could assure the questioner that appliance manufacturers were looking at the problem and trying to find ways of reducing the cost of appliance seals while eliminating the use of asbestos completely. To summarise, the alternatives were ceramic fibre seals that tended to be expensive, glass fibre seals that were only suitable for certain temperature applications, and he believed that there were metallic wire woven type seals that were also coming into use.

MR. IAN MacPHERSON (Glasgow District Council) addressed his question to the whole panel. He had been coming to Conference for a number of years and had heard of the wealth of coal and all the products derived from coal. Looking around the room there was scarcely a single article that could not be attributed to coal or what came from coal. It was a wonderful substance, and there was no doubt that coal was the wealth of the nation. However, he wondered how the National Coal Board justified the fact that it spent money in designing an appliance which would burn raw coal smokelessly. In his view that was a nonsense; it should be looking to see how much wealth could be got out of raw coal.

MR. R. PAYNE (NCB Coal Research Establishment) took up Mr. MacPherson's point first, since he was directly involved in the so-called adventure. The Board had to sell coal for burning to make a living and keep in business. The job of those in research and development was to provide all the options that they could to the users, in terms of the types of fuel available which could be burned satisfactorily. The use of raw coal in smoke reducing appliances was an alternative to the use of smokeless fuel in what he termed conventional appliance designs. On the range of options and the comparative attractions of smokeless fuel and raw coal, he said that with smokeless fuel there was a relatively low cost appliance but against that, it was a relatively expensive fuel. For raw bituminous coal, because the appliance that burned it with adequate smoke reduction for smoke control areas had to be that much more sophisticated in design, a higher first cost of the appliance was entailed. That appliance, of relatively higher cost, had the advantage of burning a fuel of relatively lower cost. The main competitor in that market area (which should not be overlooked) was natural gas. It was necessary to provide incentives to the domestic user to burn solid fuel for home heating rather than natural gas. In the burning of raw coal in specially designed high efficiency appliances, what was offered was a significant reduction in operating cost, making it extremely competitive with the cost of operating on gas fired appliances. That was the point. The Coal Board was attempting to at least retain the existing domestic market for coal, and would hopefully, with the introduction of new technology, expand that market, as well as the industrial market for coal.

MR. R. PANE (Coalite Group plc), following up the point, said that the previous speaker, Mr. Payne, was concerned with the development of Smokeater appliances. The rest of these on the panel made their living from the manufacture of solid smokeless fuels. To a large degree he agreed with what Mr. MacPherson had said. People talked about efficient burning of fuel, and one of the things laid before the public was the fact that electricity was 100% efficient. It was at the point of use! The average power station took coal and burned it at only 30% efficiency and the consumer had to pay!

Turning to the position of the Smokeater, he said that the Smokeater concept was a marvellous one. The first presentation of such an appliance had been in 1680 at the Paris Exhibition - so it had been a few hundred years in the development. In his opinion it remained an idea to be aimed at but never to be achieved. He feared that he would lose some friends with his next remarks. As those present would know, there had been two or three attempts at producing that type of appliance; if it was possible to produce a smokeater which involved the housewife merely in putting the fuel on the grate, as she did with a normal room heating appliance, and in nothing else, and it burned absolutely smoke-free, then everyone would concede that it was an excellent idea. But, if the housewife was expected to operate as a technician, loading the fuel on the appliance, watching it, and cleaning it once every three weeks - because otherwise it would not work efficiently - he did not think that the housewife would co-operate. She had enough on her plate and did not wish - nor did she have the time - to do those things. She wanted a foolproof appliance and until there was a foolproof smokeater, he suggested to the Conference that the use of manufactured solid smokeless fuel was the guarantee that would keep the air in the UK's towns and cities clean.

MR. C. KIBBLER (Rexco Ltd) said that he also was prejudiced since he made his living, his bread and butter and the occasional bit of jam on it, out of making and selling solid smokeless fuel. However, he had started out life as a psuedo-chemist, and would not wish to see technology stifled. One thing, however, bothered him somewhat. Mr. Reynolds had that morning shown a slide of the world's coal, oil and gas reserves of the world, the amount currently being used, and the time they were expected to last. However, if one took the extreme case that all smoke control areas were fitted with smokeaters or something equivalent, coal tars would no longer be produced as a by-product of manufactured solid fuels, and he felt that would mean the loss of a very valuable source of raw materials for so many things, not only the ones Mr. MacPherson had referred to, but more importantly, such things as pharmaceuticals, fertilizers and herbicides.

MR. J. BEAGLE (London Borough of Hammersmith and Fulham) wished to follow up the previous question. He said that although things had been improving for many years it was rather sad to hear that coal was going to be used in increasing quantities with the resultant increase in smoke and grit, and with all the adverse economic effects that had caused in the past. He asked the panel what steps were being taken to develop the use of solid smokeless fuels for industry because it seemed wasteful to burn off all those valuable by-products of coal as smoke. To have millions of tons of valuable by-products polluting the atmosphere was in his opinion completely and utterly counter-productive to clean air.

MR. R. PANE (Coalite Group plc) remarked that Mr. Beagle's was a good question, the basic concept of which everyone on the panel would support.

From the Nation's point of view it would be right, but energy policies by their very nature were longterm and no Government to date had been willing to produce such a policy. Indeed, the industry had been bedevilled by short term considerations and stop/go policies. Even if an economic situation clearly indicated that national benefits were to be gained by taking the longterm view, short term expediencies by the Government of the day decided otherwise. Most people in the room had experienced similar situations. In 1966 the then Minister of Energy had produced a White Paper indicating that the UK should base its future energy requirements on what had then been cheap oil and natural gas, that the coal industry should be allowed to decline. It had taken the Yom Kippur war to make the powers that be realise the importance of coal and its derivatives.

Unfortunately in the meantime natural gas had been permitted, at ridiculously low prices, to take over large tranches of the industrial and domestic market. Vast amounts of natural gas had been used for heating purposes which would have better served the nation as a chemical feed stock. Also, because of the pricing policy then decided upon, which had been to keep gas well below the cost of other forms of energy, that approach had contributed to the closure of numerous carbonisation plants.

Mr. Pane considered that to achieve the objective that the question implied, there would have to be a major change in the current energy policy thinking and special support and encouragement to further develop the carbonisation industry.

MR. M.J. SAMBROOK (National Smokeless Fuels Ltd) said that it was quite wrong to think of manufactured smokeless fuels being used purely in the domestic market; his own company's biggest single market by far was the blast furnace market for steel. The coke that went there was a smokeless fuel in just the same way as the domestic fuel. Manufactured fuel producers all supplied cokes for the ferro-alloy industry overseas. Another big customer was the British foundry industry, and although the domestic market was very important to NSF, it was certainly not the company's exclusive customer; it accounted for about 40% of his company's sales, the remainder all going to industry in one form or another, and all of it smokeless fuel.

MR. R. PAYNE (NCB, Coal Research Establishment) said that he did not wish to appear controversial. His problem was that he had a foot in both camps, i.e. of smokeless fuel and direct coal burning. He attempted to correct his colleagues' prejudices on direct coal burning and tried to answer the question. In terms of direct coal burning, the NCB was moving in the direction of the market pressures. He wanted to correct some erroneous impressions about direct coal burning appliances. He stressed that they were as efficient and as smoke-free, in atmospheric terms, as smokeless fuel appliances. A question had been raised about their convenience and use. Of the range of appliances developed at the Coal Reserch Establishment, then in commercial production, one of the first things that happened was that before the appliances were sold to the public at large, the development people who worked on them had them in their own houses and lived initially with the product. There was no better monitor of the performance of an appliance than one's own wife. She would soon say if the appliance had faults. That was then followed up with extensive market trials, up and down the country, with a cross-section of users. From all the acquired information, CRE were able to advise the manufacturer on a commercial design which was as convenient in use as smokeless fuel appliances, and as efficient in use. What he was correcting was the impression that the increased domestic coal burn would lead to increased smoke and grit in the atmosphere.

In designing appliances, both smokeless fuel appliances and coal burning appliances, CRE's terms of reference were the requirements of statutory legislation that had to be complied with, and those were the initial starting points. In terms of the performance of the appliances, CRE did not operate just below the set levels or limits, they liked to be comfortably within those limits, and that was true both in terms of the thermal efficiency of smokeless fuel appliances and in terms of grit and smoke emissions of direct coal burning appliances.

MR. S. CARDEN (Barnsley Metropolitan Borough Council) stated that the practical application of the smokeater had so far failed and there were serious enforcement problems created by smokeater appliances, which were certainly not "smokeless".

MR. R. PAYNE said he had to respond to the point made at the beginning of Mr. Carden's question. The evidence quoted was certainly not the evidence that came back through the manufacturers. CRE followed through the developed appliances beyond the commercial stage in terms of service returns. That was seen to be a very valuable way of identifying particular Achilles' heels in the design, which could then be put right, subsequently. In terms of sales' success, CRE's evidence was that the manufacturers with whom they collaborated were selling those appliances in relatively substantial numbers. He wished to make a point back to the local authorities, which stood out in the service returns analysed by CRE, and which were analysed on many counts. That was, that where the sales were made to private households, there was generally no problem; the service returns were almost nil. Where they were sold to local authority estates, there seemed to be more batches of problems. When these were followed as they always were, it was found that the appliances had in some cases been very severely abused, to the extent of, for example, roomheater windows being broken in. CRE had a catalogue of horror stories about certain council estates they had visited. For example, at some sites entrance was through the open front to the house, because the door did not exist - it had been broken up and burnt; Mr. Payne himself had been to a house where a gentleman had been seated in an armchair in front of a smoke reducing roomheater that had not had a firedoor on it, when it should have had. He had been burning a telegraph pole, one end of which had been in the firebed, and the other end he had been adjusting with his foot to provide an incremental feed system! That was the sort of severe abuse that CRE encountered, the sort they were up against. The difficulty in such cases was to make the units absolutely idiot-proof. That could be done on the industrial side, because the systems could be made fully automatic, with no user intervention, but where that could not be afforded, on the domestic front, such problems were presented. What CRE had tended to do was to simplify the design as far as possible, to make it idiot-proof.

PROGRESS IN MEETING THE EC DIRECTIVE WITH SPECIFIC REFERENCE TO SMOKE CONTROL

B.D. Gooriah and M.L. Williams, Warren Spring Laboratory

NSCA SURVEYS - 'Coal Burning in Smoke Control Areas' 'Enforcement of the Clean Air Legislation'

J. Langston, Secretary General, National Society for Clean Air

MR. I.W. BARKER (Sheffield City Council) referred to Sheffield as one of the pacemakers in the implementation of smoke control areas. The whole City, encompassing 37,000 hectares, 212,000 houses and 50,000 other buildings, was covered by operative Smoke Control Orders. In the industrial east end of the City vast areas lay dormant, victim to the deep recession, the chimneys clear but cold.

Despite those factors, which mitigated in favour of the maintenance of air quality controls, two of the five air pollution monitoring stations had been identified by Warren Spring as approaching breaches of the EEC air quality standards. The factor causing the breach in both cases was smoke concentrations approaching the trigger level, which activated the more stringent SO_2 standard.

When the reasons for that situation were examined, it was apparent that in spite of Smoke Control Areas, the burning of raw bituminous coal on domestic grates was widespread, particularly in the older established Smoke Control Areas. When the recession eased, when industrial activity revived and reasserted itself, many fuel burning plants previously relying on oil or gas would revert to coal. Thus the maintenance of existing air quality standards would become more difficult and the possibility of further deterioration had to be faced.

Regarding a solution to the problem, Mr. Barker said that the standard answer, the introduction of smoke control programmes, was not open to Sheffield. That had already been done.

Enforcement of the Smoke Control Orders was carried out by intensive surveys concentrated in specific areas. That approach was effective. For example, in one area which was only a small section of one Smoke Control Area, more than 400 householders had been found to be burning coal during a 2 day survey. Written warnings and follow-up surveys had reduced the number of contraventions and eventually 13 householders had been successfully prosecuted along with 2 coal merchants who had delivered coal. But such exercises were highly intensive of man-power and the input was purely local.

Therefore, in a situation where comprehensive smoke control had been completed, enforcement was limited by available resources and fines on those coal merchants who were apprehended were no deterrent. Mr. Barker asked whether the time had come to give serious consideration to the withdrawal of raw bituminous coal from the domestic market in its entirety.

CLLR. J. WILD (Manchester Area Council for Clean Air and Noise Control) said that speakers had referred earlier to the great value, to the public at large, of the by-products of manufactured smokeless fuels.

He asked why the large profits made from these products were not set against the cost of producing smokeless fuel, thus bringing down the end cost to the householder.

MR. M. JONES (Cynon Valley B.C.) explained that Cynon Valley was a coal mining community in the South Wales' valleys. Right in the middle of the valley was what he termed "Dante's Inferno Mark II", otherwise known as National Smokeless Fuels Ltd. Phurnacite plant, a slide of which Dr. Gibson had shown during his presentation that morning. Mr. Jones said that he would make no apology for raising the matter again (vide his remarks to Sir Derek Ezra, 1980 Clean Air Conference, Bournemouth Bournemouth).

The plant was a registered works, manufacturing solid smokeless fuel, and had been designed in the 1930's by a French company. Mr. Jones said that it was completely outdated, and deposited its filth the length and breadth of the valley. That, together with the copious yellow fumes and stinking gases emitted, had given the valley the infamous label of "the dirtiest in Europe" (quoting a Swiss newspaper article).

Sir Derek Ezra had referred to it as one of the "imponderables of life". The District Alkali Inspector believed it to be the greatest pollution problem in the UK; although he appeared to be doing his best, it was impossible to bring a 1930 machine up to 1980 standards. In the former "black areas" melanistic moths had been common as the black markings were well camouflaged against the sooted tree trunks. In the Cynon Valley, there were black ladybirds with red spots!

The local authority had applied to the Secretary of State for Wales, under the Alkali &etc. Works Regulations Act, 1906, for an enquiry to be held following literally thousands of complaints. However, the Secretary of State had in his wisdom turned down the application. Mr. Jones could only suppose that the Welsh Secretary's mind had been clouded by the Phurnacite plant.

The plant provided 15% of the UK's requirement for solid smokeless fuel, a product which, it had been pointed out that day, would be increasingly essential in the future for the maintenance of clean air, as oil, and particularly, gas supplies dwindled.

Cynon Valley needed a new process plant, one favoured by all and sundry including the Unions, the Alkali Inspectorate and the local authority. The Ancit process seemed to be the answer, but capital for the substantial investment required was not forthcoming from Government.

Mr. Jones wondered where next to turn. in order to secure help for the 70,000 people living in such intolerable conditions. He asked his old friend and classmate, Dr. Williams of WSL, to visit Cynon Valley with an open andindependent mind, to measure the pollution levels (which Mr. Jones was certain would be in breach of the EC Directive) and to present the results to the Government so that they would realise the plight of the people living in Cynon Valley. He said finally that if anyone else had any valid suggestions, short of explosives, he would be only too pleased to listen.

MR. M.J. SAMBROOK (NSF Ltd), replying to comments made by Mr. Jones, said that the environmental problems at the Works arose from three main factors:-

(i) the physical handling and processing of some 900,000 tonnes of coal and 700,000 tonnes of Phurnacite each year inevitably gave rise to dust which it was difficult to control completely;

(ii) the process itself was out of date and did not meet modern pollution control requirements. Despite intensive efforts and substantial investment it had not been possible fully to overcome the inherent problems of the process. The problem was compounded by the age of the Works which made it more difficult to maintain the best standards of operation and minimise the environmental impact;

(iii) the "micro-climate" in the Cynon Valley compounded the problem of pollution. The valley was subject to temperature inversions which trapped any emissions from the works, concentrating the effect.

After an investigation into pollution at the Works carried out by a team which included representatives of N.S.F., the Local Authority and independent consultants, a 14 point programme of anti-pollution measures had been agreed and started upon in 1979. Some of the projects in the programme were capable of being put in hand fairly quickly; others required feasibility studies and research prior to implementation. The total commitment by N.S.F. to improving the environment at Abercwmboi was over £4m., of which £3m. had already been spent.

In addition, N.S.F. had taken a number of other steps to improve the local environment, including the removal of a stockpile near the Works boundary, grassing and tree planting and an improved cleaning programme at the Works.

N.S.F. had also undertaken other measures which, although related to operational requirements, had contributed to the control of emissions. The main items had been a programme of extensive repairs to the batteries to overcome the problems associated with age, and an extension of the period of carbonising the briquettes which had had the effect of reducing pollution on discharge.

N.S.F. considered that the measures adopted demonstrated a determination to do whatever was possible to improve the environment around the Works within the constraints of the company's difficult financial situation and the Inspectorate had acknowledged that there had been an improvement.

It had to be recognised, however, that the inherent problems of the Disticoke process placed a finite limit on what could be achieved. It was for this reason that N.S.F. had decided in the 1970s that further rebuilds of the Phurnacite batteries on the Disticoke process should not be carried out. A search had been made for alternative processes that were more modern, and had a much lower level of pollution whilst producing a fuel that was of comparable quality to Phurnacite and could supplement Phurnacite in the market.

After extensive investigations, it had been concluded that the process most suited to the company's needs was the Ancit process, developed in Germany. Visits to a German Ancit plant had demonstrated both to N.S.F. and to the Alkali Inspectorate that Ancit would be an acceptable alternative to the Disticoke process both technically and by virtue of the much reduced level of emissions.

In 1979, N.S.F. had prepared a scheme for replacing the two oldest of the six Phurnacite batteries by an Ancit plant. However, the economics of the scheme were such that it could not be financially justified unless the whole of the capital required - some £35m. - could be provided free of interest, and an application had been made for Government support in the context of the Tri-Partite Investigation into the Welsh coalfield. The Government ultimately in June 1981 declined to give any assistance and the scheme could not therefore proceed.

N.S.F. had not, however, abandoned the Ancit process: it was still considered to be the best technical and environmental alternative to the Disticoke process. N.S.F. had continued to examine whether a scheme could be devised to produce Ancit that could be financially justified in its own right.

Mr. Sambrook added that it was ironic that the plant, which was the single biggest contributor to clean air in the U.K., providing as it did 15% of the smokeless fuel Britain consumed over a year should create environmental problems in its immediate vicinity but the plant was the important source of local employment and wealth. About 900 people were employed at the Phurnacite plant and its consumption of South Wales coal kept a further 3,000 local miners in work. So closure would be a big threat to local employment; before the current recession had reached its peak and when unempoyment levels had been much lower than currently, the Local Authority had estimated that closure of the plant would lift local unemployment over 30%.

DR. M.L. WILLIAMS, replying to comments made by Mr. Jones, said that having grown up in the area and indeed attended the nearby Grammar School, he had been aware of the local concern over the Phurnacite plant for many years. However, WSL could not of its own volition carry out a pollution study as suggested by Mr. Jones, even if it could be agreed that such a study would in fact contribute to the solution of the problem; one or more of the Organisations concerned with the plant would need to invite and fund the laboratory to carry out a mutually agreed investigation.

WEDNESDAY 20 OCTOBER

MORNING
SESSION FOUR (PART 1)

PUBLIC EDUCATION IN NOISE
J. Bickerdike, Principal Lecturer in
Environmental Health, Leeds Polytechnic
NOISE ABATEMENT ZONES - CAN THEY BE MADE
TO WORK?
J.F. Barraclough, Assistant Chief
Environmental Health Officer, Calderdale MBC
COFFEE
CONTROL OF NOISE BY PLANNING
M.S. Ankers, Principal Environmental Health
Officer, City of Manchester.

MR. D. CLARK (Middlesbrough B.C.) opening the discussion, supposed that everyone who accepted an invitation to open a discussion period awaited with interest the arrival of the papers before Conference.

He asked delegates to imagine how his heart had sunk when he had seen that Mr. Bickerdike's paper was simply one piece of paper outlining his thoughts. However, he had realised that Mr. Bickerdike was a professional communicator who in due course would reveal all, as he had indeed done.

Mr. Bickerdike had presented a working broadsheet on how to set about an effective education programme. Mr. Clark felt that his comments and advice were timely, because as everyone in local authority realised, money, and therefore staff time, was in very short supply. As a result there was pressure on health education programmes, the temptation being to reduce them to a leaflet distribution and display mounting exercise. There were two dangers inherent in this approach; first, that the level of complaints might rise as a result of the turn-down of preventive work, and secondly, that what little time was spent might have been wasted because the programme was not properly structured. He agreed that the axing of the Noise Advisory Council had been a disaster in this respect, and relied on the

Society and the professions to ensure that such traps were avoided in the future.

Mr. Bickerdike's mention of the education of union officials on hearing conservation had reminded Mr. Clark of one union official who had declared his satisfaction with a factory simply because ear defenders had been provided. The Code of Practice stated that noise should be reduced wherever possible. That union official had needed educating, but on a continuing basis, because there would always be the temptation to go for the soft option - including a window dressing education programme.

Turning to Mr. Barraclough's paper, "Noise Abatement" Zones - can they be made to work?", Mr. Clark had again been a little worried about his role, as he was a supporter of Noise Abatement Zones. He was prepared to admit publicly to that sinful failing; he realised that his colleagues might not want to drink with him that evening, but he felt that the truth had to come out.

Middlesbrough had had two zones in operation for six or more years, with a third on the way.It was hoped that the happy event might be in the Spring of 1983. Therefore, he had thought that he might simply have to agree with everything Mr. Barraclough had to say. However, he was able to thank him for providing some controversial comments; Mr. Clark was able to disagree with much in the paper, sometimes quite profoundly.

The first such conflict arose in paragraph 2 on page 2, with the statement that "noise nuisance can be controlled by sections 58 and 59 of the Control of Pollution Act in conjunction with BS 4142."
Mr. Clark said that that was not strictly accurate, because BS 4142 had no legal standing, for reasons to which he would return later. It was merely a guide, and there were others, including the subjective judgement of a magistrate.

Later in the same paragraph it was stated that sections 58 and 59 did not take account of the need to prevent the escalation of noise. Mr. Clark said that that was not strictly true, since one of the significant changes in the law of noise nuisance on the demise of the Noise Abatement Act, had been the prevention of a noise nuisance occurring or recurring. All those points had been made under the heading "The need for control". Clearly both he and Mr. Barraclough agreed on the need, but disagreed on the justification. His own justification was quite simple - at times there was no other way. Like that famous beer, Noise Abatement Zones reached parts of the noise pollution problem other techniques could not reach. They were part of the total armoury of anti noise measures.

Turning to Mr. Barraclough's "Criteria for success", Mr. Clarke said that much had already been said at the Conference about cost/benefit analysis. He was extremely worried about its over enthusiastic use in the environmental field. There might be a place for it in the selection of the most appropriate boiler plant, but rarely in the selection of environmental policy; for example, whether to make a smoke control order or even to take lead out of petrol. He had been involved in several epidemiological studies into the health effects of pollutants; they were always complicated by awkward little facts such as that everyone was not built the same way.

As a result, the findings of such studies were usually carefully worded declarations of probability. He questioned therefore, whether it was accurate to take such statements, and compare them with a costing prepared by a diligent accountant. He was not even sure whether it was ethical to do so, because some pretty unsavoury decisions could be taken by accident in such a process. Specific to the paper he asked how much 1 dBA was worth, and, more difficult still, what was the value of 1 dBA which would have arisen if it had not been for a Noise Abatement Zone?

He agreed with Mr. Barraclough's analysis of the alternatives to Noise Abatement Zones. However, a point of detail jarred. At the bottom of page 3 there had appeared the following phrase alluding to the insulation of houses against extraneous noise: "Presumably the polluter would be required to pay either in total or in part". Mr. Clarke said that the "polluter pays principle" was another of his hobby horses. Other than the Common Law and the Government's own responsibilities under traffic noise legislation, he was not aware of any laws which allowed such a principle to be upheld in the circumstances outlined. It was extremely difficult to require that something be done on someone else's property; however, he said that he would be pleased to be enlightened on the point.

On page 4 (para 7), Mr. Barraclough had written that it was impractical to attempt community noise readings which would satisfy all recipients. The Wilson Committee had tried to do so in 1963, and that report had formed the basis of BS 4142. It did not satisfy all recipients. It was only possible to please some of the people some of the time. That was why BS 4142 did not have any legislative standing as he had remarked earlier.

Taking issue with the reference to a planning control standard at the top of page 5, Mr. Clark said that he realised that those numbers came from a circular, but they did tend to be used as pass/fail standards, and he said he would welcome the views of all the authors on that point.

Mr. Clark admitted that he appeared to be paying perhaps too much critical attention to Mr.Barraclough's paper; there was, however, much in it with which he disagreed. There seemed to him to be a degree of over-attention to Noise Reduction Notices throughout the paper, in that they were anticipated on declaration of a Zone. He himself had always looked upon Noise Reduction Notices as "phase 2 notices", to be used once the upward creep of background levels had been arrested, in order to secure a positive reduction in levels.

In the middle of page 8 was a paragraph examining the rights and wrongs of including domestic premises in the schedule. That had startled Mr. Clark, since it was his understanding of the Act that one could not include domestic premises in any event; from the discussion, however, it appeared that Mr.Barraclough had been referring to an education programme.

He had been similarly startled to read on page 9 a recommendation to negotiate a reduction in noise levels prior to registering them, using a Noise Reduction Notice as a sort of 'sword of Damocles' in case of non-agreement. In Mr. Barraclough's presentation, however, he had said he had not served any Notices and had been referring only to those cases where a nuisance already existed. Mr. Clark wondered why, in such circumstances, he did not simply use s.58.

On the question of public reaction, Mr. Clark thought that the phrase "Noise Control Zone" was preferable, since the word "Abatement" raised expectations.

Mr. Clark apologised for spending so much time on one paper, explaining that he was aware, from being involved in debates on the subject, that Noise Abatement Zones were not universally popular among local authorities. He had attempted to get some points of detail out of the way in the hope that a debate on the pro's and con's would come from the floor.

Turning finally to Mr. Ankers' paper, "The Control of Noise by Planning", Mr. Clark expressed the view that it was an excellent paper, and carefully reasoned; he said he would be showing it around his Authority when he returned.Mr. Ankers had reminded the audience and a wider readership of the need and relevance of the use of planning powers as an essential part of noise control.

He could only echo Mr. Ankers' amazement about Circular 10/73,'Planning and Noise': that it might appear strange to outsiders that positive and reasonable advice given by Government almost ten years previously had still to be explained to both officers and members. Mr. Clark thought that it was indeed strange, when the consequences of not heeding that advice could be so expensive and disturbing to the general public.

MR. J. BICKERDIKE, replying to Mr. Clark, apologised for not having provided a full copy of his paper before the conference; that had been due to other pressures on his time, and had been agreed by the organisers. He also found it a good ploy to avoid excessive criticism!

As Mr. Clark had suggested, there was always a temptation to go for the 'soft option'; in the case of noise, the soft option was not an educational programme but statutory control, as that produced the quickest results. Education was not a soft option; it had to be worked at over a long period if results were to be meaningful and lasting. It was all too easy for local authorities, in a period of staff shortages and financial constraints, to use the 'stick' rather than the 'carrot'. If educational programmes were to be introduced for noise problems then the government had to be prepared to invest resources, otherwise they would fail. However, local authorities and the Environmental Health Departments in particular could and should make a start in raising the level of awareness of noise problems in the general public, and he suggested that domestic noise might be a good area in which to make a start.

He was pleased that Mr. Clark agreed with him that the axing of the NAC had been a disaster. What was lacking was a body which could look at the whole range of noise problems and determine priorities. He knew that the Institute of Acoustics was in the process of trying to form a Noise Council, to which he hoped that the NSCA would make a contribution.

MR. M.S. ANKERS, replying, said that it was unacceptable to expect a polluter to provide double glazing to a house and then to have a subsequent occupier of the house take out the double glazing and insist that the local authority take action against the polluter for causing a noise nuisance. Neither was it, in his view, reasonable for the polluter to say to the person who lived in the house, "Oh well you can always put double glazing in and I will pay for it". That was still interference with the rights of the occupier, who then had to have a double glazed window kept closed. Mr. Ankers said that he knew of one or two local authorities who had diverted funds into sort of area, but it was not a course of action that he would gladly promote. He commented that it would be possible to do it in the case of L.A. housing but only by Section 52 agreements; it could not be done as a normal part of a planning process because a planning condition could only apply to the application site.

Mr. Ankers remarked that Mr. Clark had asked him some nice leading questions, particularly, what he would do in the case of premises complying with an existing planning condition but emitting noise, although not at a level which was actionable as a noise nuisance, and/or where the "best practicable means" defence was available. Mr. Ankers commented that, as the Irishman said, he would not start from there; rather than beg the question in that way, he would, he believed, have accepted that there was a problem, and would devote some time to sorting it out. He did not believe that he and his colleagues in Manchester were unique; however, they did seem to have an uncommonly good relationship with industrialists in the area. Times were hard, and clearly industrialists were not going to put their hands into their pockets quite as readily as they had done previously.

With reference to noise abatement zones, Mr. Ankers said that he had not been asked to give a paper on that subject, but in his view the procedure was a long way round to achieve effective control. Mr. Clark had, he felt quite rightly, said that a noise reduction notice was a powerful tool, but Mr. Ankers could see no reason for following the complicated procedure of setting up a noise abatement zone in order to use the power to serve a noise reduction notice. He considered that there were plenty of safeguards in Section 66 for a local authority to be able to use a noise reduction notice without having to go through a noise abatement zone procedure. His main objection to NAZs was the sheer magnitude of the problem of setting up a noise abatement zone properly, in order to achieve what, in his view, were possibly unquantifiable and very long term benefits - when the same resources could be used to immediate effect.

MR. H.R. NOWELL (Bath City Council) wished to comment on both Mr. Bickerdike's and Mr. Barraclough's presentations, levelling criticism at the concept of noise abatement zones. He believed that they were an excessively bureaucratic method of dealing with noise which was not a nuisance, requiring expenditure of manpower, equipment and administration which was greatly disproportionate to the benefit gained. Although he might be old fashioned, he thought local authorities were in business to respond to the needs of the community. He simply sought to find out what types of noise the community wanted to be controlled, and the answer, from monitoring, complaint and social surveys, was not the possible prevention of a creeping increase in background levels, but noise from traffic and domestic noise. Unfortunately, he had to dismiss traffic noise for the purpose of his comments because local authorities had little or no power in that regard, and the ball was firmly in central government's court to take the initiative, to provide realistic, effective and enforceable controls.

Turning to noise from domestic sources, he said that Mr. Bickerdike had demonstrated how educational programmes could contribute to individual and public awareness of noise problems and improvement in noise climates. Mr. Barraclough had made reference to it as an ingredient of a successful noise abatement zone. At a time when domestic noise was a dominant source of complaint to local authorities, Mr. Nowell suggested that local authorities should respond to the needs of their community, and direct attention towards an education and enforcement programme in that field, rather than pursue a costly and time consuming noise abatement zone policy directed towards control of industrial noise, for which adequate control measures through nuisance and planning laws already existed, and which industry would hold as unnecessary and distractive from its major aim, certainly in the first half of this decade, of survival and hence the preservation of employment.

MR. BICKERDIKE commented that, as his slide (Fig.2) had shown, domestic complaints were almost double those about industrial and commercial sources. So he intended to tackle the domestic problem first, which was one which might respond best to an education programme. Since the domestic environment was where the majority of people experienced and produced noise, education concerning domestic noise was a priority. They might also experience both commercial and industrial noise, but domestic noise was difficult to control from a statutory point of view and so was one of the principal areas in which progress might be made.

MR. J.F. BARRACLOUGH, replying, said that people talked about protection of the environment, and about a peaceful and quiet existence. The real issue was public reaction. If a complaint was considered to be justified and was actionable under the nuisance procedures, that was fine, but noise abatement zone work was concerned with noise which did not amount to a nuisance, but nevertheless was in the first instance, controllable, in order to ensure first that it did not escalate, and secondly, that it could be reduced if it was practical to do so. Nuisance was not the point at issue, it was control of the situation and an attempt to improve it. It did not have to cost a lot of money; as he had said that morning, the resource in terms of manpower and finance that his council had put into the work was minimal. For what they had got out of it, it was, he considered, well worth while.

MR. BICKERDIKE said that if noise abatement zones were to be adopted, it was certainly essential to have an educational programme first.

MR. K. TEESDALE (Ford Motor Co.) had a question for Mr. Bickerdike on this subject which he considered to be of crucial importance. He fully supported the need for effective education programmes on emotive topics like noise, juggernauts, and lead in petrol. However, since the Government had turned its face against central planning, QUANGOs, local regional bureaucracies and so on, the only approach left was one of direct campaigning and opposition. As a result, the public were bombarded by conflicting lobbies on very complex technical subjects and tended to switch off. Surely, therefore, there was a need for an effective middle ground, perhaps covering the following three areas:

First, that Government, whatever its political shade of opinion, must interest itself in some positive way in the reduction of adverse effects, whether of noise or other pollutants.

Secondly, there was a desperate need for some kind of co-ordinating body, particularly in such times of diminishing resources. Such a body might be a learned society or professional association, or indeed such as the NSCA, which had a commendable record of objectivity and control, but it was vital to centralise research activities and to avoid duplication. And thirdly, ultimate success depended - as every speaker had pointed out that morning - on support at the grass roots level. Local people had to be convinced.

So the question was whether Mr. Bickerdike would agree that there was a need for a middle approach, and if so, on what lines or through what groups it could be effectively launched and implemented.

MR. BICKERDIKE expressed complete agreement with Mr. Teesdale's views on government's responsibility, which was why, at the beginning of his action groups, he had placed that action at a national level firmly in the government's court. As far as a national body was concerned, the demise of NAC was a retrograde step, especially since it cost very little to operate and its disbandment meant the disappearance of any national policy.

However, on the subject of a co-ordinating body, IOA (the Institute of Acoustics) was negotiating with some of the leading members of the old NAC in order to try and revive that body as a Noise Council. Certainly the NSCA should participate since there was a need for a multi-party group. It would have to be one which organised itself across the whole range of activities: industry, laymen, professionals, etc., in order that it could point the way towards research, statutory needs and future policies and priorities. Mr. Bickerdike said that he would keenly support such a group.

At the gass-roots level, then, self-motivation could only occur through small group discussions and it was there that local authorities and particularly the environmental health officer had a central role to play.

MR. D. BIRD (Yorkshire & Humberside Division, NSCA) said that Sheffield,as many people knew, had two noise abatement zones, but he would not advocate their creation using existing resources. If a local authority had a programme which was working successfully with the resources available, there was no point in creating a noise abatement zone for its own sake. Sheffield had its NAZs by the grace of central government, with two technical officers, not environmental health officers, to administer them. Mr. Bird's suggestion was that those present should approach their councils to see whether or not they were prepared to spend ratepayers' money on providing extra staffing resource.

The other point he wished to take up from John Barraclough's paper was that it was a nonsense to say that noise abatement zones did not cost very much. Salary and time were costly, and time was a valuable resource. It was up to Environmental Health Depts. to make the most of such resources by developing programmes that actually furthered their aims. His advice to the doubting was: "Suck one and see!" If a small one were used as an adjunct to planning control, then it could work.

Mr. Bird did not support the idea of public education programmes in noise abatement zones, since he believed that NAZs were for the public, but did not necessarily involve them. He personally had not involved the public in any of the consultations about noise abatement zones because if there has been any doubt about public support for such a project it would not have been undertaken in the first place. In any case it was a waste of local authority resources to try to educate the public about domestic noise: that was a job for central government. It would be futile to educate the public on domestic noise locally, without the resources to take action when approached for help.

The concept of a programme of noise abatement zones was one to which Mr. Bird was opposed: there were tight criteria for selecting NAZS and they could be made to work only in very specific locations. Principally, a political decision had to be made at the very basis of the planning stage, when an area was selected in which people, industry and commerce could co-exist with suitable environmental controls imposed on the area. For it was important to recognise that controls would be imposed on industry: noise reduction notices had to be used.(There would be no second chance once the levels had been registered). One had to deal frankly with industrialists in noise abatement zones and not prevaricate with nebulous consultations.

Certain authorities had successfully evolved pollution prevention panels and other bodies; but they worked because they had been developed over a number of years with careful consideration. The response of industrialists in the Sheffield area was proportionate to the attention paid them by the technical officers - which was considerable in noise abatement zones. They were compelled to think about noise and such compulsion produced a dialogue. Over years of liaison with industry, the only positive progress which had been made on the issue of noise, had started in noise abatement zones, and had then spread further outside.

MR. R. FIELDING (Blackpool Borough Council) wished to raise the question of whether planning conditions were being used to duplicate existing powers, or possibly even to upgrade existing powers. For example, a large number of complaints occurred between neighbours, in many cases between neighbours in flats. The Building Regulations required minimum levels of noise insulation for new flats, but apparently they could not be applied to conversions of existing buildings. He asked whether Mr. Ankers would agree that that was an oversight which could properly be corrected by the use of planning conditions.

MR. ANKERS remarked that it might have been a deliberate oversight. It could be corrected by use of planning conditions, but thereby hung a different tale. The Manchester Area Council for Clean Air and Noise Control had done some work on Part G of the Building Regulations. The problem was that the remedies for poor acoustic performance following flat conversions were not very easy. He said that people talked glibly about upgrading party wall insulation, forgetting all about flanking transmission. They could end up with massive walls and floors, and sometimes massive ceilings as well, and yet noise would go out of one window and through the next one. He thought that the main reason why it had been omitted from the Building Regulations was precisely because of that unsatisfactory situation. One or two of his colleagues had actually used planning conditions which related to that aspect; Mr. Ankers said that if Mr. Fielding wished to speak to him subsequently, he would put him in touch with somebody who had made a special study of the matter and had drawn up a series of standard conditions which were very well researched, but which were not universally applicable.

CLLR. M.T. HEYDEMAN (Reading B.C.) said that he was aware of some conflict, in the matter, between one type of education and another. Education was a dual concept which, on the one hand, aimed to develop the full potential of an individual; on the other hand tried to fit the individual for his role in society. This was true at every level and not least in the question of noise.

People were led to believe that a quiet life was desirable and at the same time had to be persuaded to accept noise as a necessary part of life, because industry had to continue to function. Thus there appeared to be a conflict between the environmental health officer, whose main desire was to keep everyone in his patch happy, and societies such as the NSCA whose concern was to improve and maintain the quality of life in such things as noise, which necessarily included increasing sensitivities of people and making them complain more and not less. That accounted, perhaps, for the kind of ambivalence which existed with regard to noise control zones. One the one hand everyone who valued quiet would wish to increase the level of public awareness; on the other hand those who had to deal with complaints, as he himself did as a Councillor, wished people to be very tolerant. There was no easy solution, but despite short term difficulties, the improvement of public awareness of noise would surely be valuable for the future. Therefore, Cllr. Heydeman suggested, Mr. Barraclough was doing a good job in increasing the number of complaints from his area. It might not be comfortable for him and it might be costing money, but it was right to make people insist on better sound insulation and on lower noise output. That sort of pressure, not only at local level but ultimately at national level, was the only way of preventing a further slide to a still noisier environment. The existing ambient noise in G.B. would not be tolerated by people of many countries, even for a day. It would not have been tolerated by Britons 200 years ago and would have been regarded as quite impossible to live with. If standards were to be preserved they had to educate for public awareness and increase pressure on central government.

MR. G. R. CHARNLEY (Southampton City Council) returned to the educational aspect, referring to Mr. Bickerdike's mention of the dramatic increase in domestic noise complaints. These were not only due to poor construction standards (not necessarily those laid down in the Building Regulations, rather, a job insufficiently well done) but also to social problems and attitudes. When people were housed and expected to live side by side in little boxes, tolerance was brought very much to the fore. Considerate behaviour and responsible attitudes in society were paramount. It appeared, however, that parents were forgetting to teach their children what responsible behaviour entailed.

Mr. Charnley sought advice from Mr. Bickerdike as to what role the EHO had in such circumstances, bearing in mind the fact the EHOs were not over-numerous and could not solve every problem at a moment's notice.

With the adult population, re-education rather than education was required, to eradicate inbuilt attitudes. In relation to children, Mr. Charnley wondered whether the problem was being tackled at a sufficiently early age; he considered that it might be necessary to start the process of education about noise at first schools, or even in play-groups. His own four year old son had shown him recently that an attitude against litter dropping,with consequent condemnation of adults who dropped litter,could be fostered very early on and he considered that the same training could be effected with regard to noise; if people were educated young enough, then perhaps the influence would be felt throughout society.

MR. BICKERDIKE agreed with Mr. Charnley's analysis: the only way to tackle the long term problem effectively as opposed to specific problems like domestic complaints, was to get the message across to young children. In other countries there were people actually promoting that message to the young. For instances the project book which he had obtained from The Netherlands, and which was used in schools there, actually set projects on noise problems; there was a noise awareness campaign at school level for the 7 or 8 year olds. In America in some States they also had similar awareness programmes in schools. To consider the points made earlier about awareness, noise control laws, noise abatement zones and statutory powers certainly created awareness i.e. everbody knew that the problem existed. But to tackle the problem itself, actually to make people respond by better behaviour, one had to motivate the public through an understanding of the problem. That part of the problem had not yet been tackled.

In the existing situation of staff shortages it was clear that EHOs were not going to be able to spend the time which was necessary to tackle the problem effectively. In fact the time-consuming nature of the task really made it the responsibility of central government to allocate the resources. However, the issue had to be tackled by both central and local government; the most effective role that central government could play on a national basis was to inform; to inform and promote local authority action at the local level.

In conclusion, Mr. Bickerdike supported the long-term approach of tackling existing problems through the educational system.

MR. S. CARDEN (Barnsley Metropolitan Borough Council) drew attention to the problems of using the A weighting network when assessing community noise problems with low frequency components and asked if the speakers agreed that circular 10/73 and B.S. 4142 should be rewritten as a matter of urgency.

MR. BICKERDIKE, replying, said that 'A' weighting was a very difficult issue, which could not effectively be debated on the basis of a few minutes' discussion. There certainly were people who felt that the 'A' weighting did not fully represent public response in certain specific instance,particularly where noises were frequency-biased. However, the frequency component of the sound could be taken into account within BS 4142 or Noise Rating Curves or NC curves. Correction factors could be added. Whether that correction factor was correct or not in the case of BS 4142 when tonal qualities of the sound were taken into account, was open to question and there might be a case for some revision. The British Standard Committee was looking into the revision of BS 4142.

The committee probably recognised that that issue might well be looked at a bit more, although it might now be necessary to wait for the revised ISO 1996. The essential thing was to make assessments as simple as possible and a return to the method of measuring octave or third octave bands would certainly complicate the measurement, adding to the resource issue and problems of time. He felt that suitable corrections could be made to the 'A' weighting, therefore he generally supported the 'A' weighting in that respect. He believed that there was a definite need for revision of 10/73 and BS 4142 for many other reasons, other than its use of 'A' weighting, but those were issues which demanded greater time for discussion.

MR. ANKERS agreed with Mr. Bickerdike, saying that while 'A' weighting was not a universal descriptor, it was simply the best available at present. Circular 10/73 was in the course of revision and hopefully would be published during 1983, or soon thereafter. He did not think that a revision of BS 4142 would ever be published because it would be overtaken by events with the adoption of the appropriate and rather different ISO publication. His inside information was that the ISO publication would be unlike anything that had ever been seen before - which could be taken however people wished!

MR. BARRACLOUGH added that anything that made life simple was to be applauded.

MR. H. DAWSON (Chairman), closing the discussion, said that a very clear message had emerged during the morning. While debate and argument would continue to rage, the educational role of all those involved in noise control had to be advanced, particularly in terms of the dual concept mentioned. Consideration had to be given to noise units, to the legislation employed, and most important of all, to the attitudes to noise. That message had to register and stick, particularly in the minds of younger NSCA members. It should be remembered in any discussion of noise that it involved an assault on the senses.

WEDNESDAY AFTERNOON
SESSION FOUR (PART II)

REDUCTION OF NOISE FROM HEAVY COMMERCIAL VEHICLES: THE TRRL QUIET HEAVY VEHICLE PROJECT

J.W. Tyler, lately of TRRL, Department
of Transport

THE CONTROL OF NOISE FROM CONSTRUCTION SITES

R.H. Clough, Wimpey Laboratories

MR. G.N. CHARNLEY (Southampton City Council) expressed his pleasure at being invited to open the discussion on such important subjects as noise from the internal combustion engine (or the "infernal" combustion engine) and construction site noise.

Knowing the broad scope of research work at the T.R.R.L., he hoped that Mr. Tyler would not mind if he widened the interpretation of noise from heavy commercial vehicles to traffic noise in general. The QHV project was a masterpiece of British achievement. As in the case of the Bionic Man, they had the technology but the "will" amongst those who wielded power was definitely questionable. The EEC happily played at setting standards for lawn mowers whilst British technology fully tried and tested four years previously lay dormant and HGV's continued to thunder along the roads.

In terms of traffic noise in general, they should not forget that they were themsleves polluters, if drivers or passengers. Instead of building-in quietness, hush-kits were bought off the shelf at the local car spares shop. When would car salesmen start to push the whispering smoothness of their vehicles instead of throaty acceleration capabilities; the everyday runabout did not have to be a Rolls-Royce to achieve that objective.

Mr. Tyler had admitted in his paper to having ignored vehicle body rattles, but in terms of tackling vehicle noise problems at source, Mr. Charnley wondered what effect the increasing number of pot holes and loose manhole covers appearing in the ever deteriorating roads would have, not only on the vehicles but on the public's peace of mind.

One could not dismiss vehicle noise without mentioning the motor-bike; especially that one with the baffles removed as its rider, pouring scorn on the community, roared down the road late at night. When the police 'did' him for speeding, might it not be possible to send him and his bike within a fixed - say 3 hour - period to report to a local test centre (which could even be at the local police station.) Admittedly the law would need some amendment but if it was possible to test speedway bikes acoustically by fairly straightforward methods, then surely this was not beyond the wit of legislators and within the capabilities of the average police constable. Turning to matters more within the grasp of local authorities, Mr. Charnley had some questions pertinent to their field of interest, which they might like to consider.

1. Did any liaison exist between the Environmental Health Department, the Highway Authority and the Planning Authorities and if so, how effective was it and what had it achieved in terms of minimising adverse impact of traffic noise and pollution?
2. Did the local authority give any consideration to the siting and protection of new housing and other sensitive developments near existing main traffic routes?
3. Was there a problem caused by the overnight parking of HGV's in the residential areas of the local authority and if so how was it being tackled?
4. Had the planners considered existing blight on houses caused by traffic noise and pollution in the preparation of local plans?

Those were only a few of the questions to which satisfactory answers should be sought. As for vehicle noise in the future, hybrids and electric vehicles were being developed and tested. Perhaps here lay the great breakthrough in traffic noise reduction.

Turning to construction noise, Mr. Charnley first wished to pay a tribute to the committee which had developed B.S. 5228 for thoughtfully giving EHOs Saturday afternoon as part of the normal working day, and for deciding that 75 dB(A) Leq was the norm; that perhaps had not been their intention but rather the interpretation in practice.

He wondered what had happened to the predictions of all those punduits who had said that local authorities would be snowed under with applications for prior consents; in Southampton those applications could be counted annually on the fingers of one hand and were generally concerned with major road construction and sewerage contracts. One such application the previous year had involved operating a large drilling rig day and night in the heart of the City in close proximity to a block of flats, when residents had withstood fairly steady sound levels of 60 dB(A) throughout the night without complaint. Even though that had been "silenced" rig drilling for geothermal energy, the general conclusion had been that the excellent public relations before and during the works (which lasted well over 2 months) had done much to alleviate concern.

No doubt everyone had heard of the "3T's" for efficient combustion (time, temperature and turbulence): Mr. Charnley suggested the 3T's for construction and demolition contractors to help prevent a conflagration in the neighbourhood (to be used at the pre-tendering stage):-

T1 - Thinking about the likely effects of the operation on the neighbourhood, choosing the most suitable plant, designing site layout and deciding whether prior consent should be sought.

T2 - Timing time of the year to cause least disturbance, days of the week and time of the day.

T3 - Telling the local authority Environmental Health Department what was about to happen;

> telling local residents by letter (and in some cases by public meetings and through local press and radio) what works were being undertaken, their likely duration, what special precautions had been taken for their protection, (e.g. silenced plant in use), who to contact in case of problems and finally not forgetting to apologise for any inconvenience which might be caused.

Simple etiquette could buy a bag full of decibels at very low cost when compared with high cost silencing techniques for plant.

The mention of public relations in Mr. Clough's paper had been most welcome and Mr. Charnley wished to take exception to only one point, which he quoted: "the responsibility for controlling construction site noise lies primarily with the local authority via their Environmental Health Department ...". Day in and day out the world of industry and commerce bemoaned the bureaucratic controls which beset them. Much of the raison d'etre behind the existence of noise and pollution control agencies lay in industry's failure to recognise their primary responsibilities towards the communities within which they operated. It was not the Environmental Health Department which was primarily responsible, but industry, as represented by Mr. Clough.

MR. TYLER wished to thank Mr. Charnley for his kind comments on the QHV project, which had been a very successful one. Personally, rather than as a member of TRRL, he agreed with Mr. Charnley that they had to wait for the EEC to make up its mind in discussions in Brussels about the date for reducing noise from all classes of vehicles, particularly the heavy goods vehicle, and details of what the levels and timing were to be. As he had mentioned in his paper the last EEC directive called for 80 dB(A) for all vehicles by 1985, but obviously that was not going to happen. Mr. Tyler said that he did not know what the values of noise level or the timing were going to be, but it was obviously extremely important that they be known as soon as possible.

MR. R. CLOUGH pointed out that he was referring to the situation as it was, not as it should be. He had been trying to make the point that the responsibility under the Control of Pollution Act for enforcement of noise limits was that of the local authority. He had not been trying to evade the contractor's duty to work in a responsible fashion.

MR. G. HOLMES (Reading B.C.) referred to Mr. Tyler's statement that an estimated 12%, or millions of people in the country, were very much or considerably disturbed in their homes by lorry noise; yet the Ministry of Transport was proposing to introduce even heavier lorries. He believed, as did his Council, that the public generally and even Members of Parliament were being misled into accepting those heavier lorries by spurious arguments. For example, they were said to be more economical. They were indeed, to the users, because the public was of course subsidising those firms and subsidising them heavily, through damage to roads, bridges and buildings - cars and bicycles did not do all that damage - and subsidising them through human life, because an accident with a heavy lorry was more likely to be fatal. The public were subsidising them by suffering increased danger from blinding spray - and heavier lorries with more axles would be even worse. It would not be possible to get rid of heavy lorries, but he and his Council felt that they should not be heavier until there were safer roads.

The manufacturers certainly would not make lorries quieter until they had to, because the cost would be so much greater and they had to sell them. The public were told that there would be fewer of them, yet the last time the weights of vehicles had been increased, so had the number of vehicles. The public had been told that the quiet heavy lorry, which was such a marvellous vehicle, would probably be in business by 1985; but that day conference had heard, which was surely a great disappointment, that it might not be widely available until

1995, if then. He wondered, in some despair, what sort of programme that was. He believed that if lorries were to be made heavier, they should at the same time be made quieter. The UK did not have to wait for the EEC to catch up; the UK could lead the EEC for a change. The technology existed, and UK industry should go out and sell it.

Another misleading factor was the omission of low frequency noise in the dBA measurements. Unlike noise from cars, which contained few low frequency components, lorry noise caused much disturbance to people's homes, because the low frequencies penetrated buildings and set up vibration. Mr. Holmes asked Mr. Tyler whether he felt that to give a true expression of the noise of current heavy lorries (which would probably be about for the next 15 years or more) a scale should be introduced whereby the lower frequencies were not weighted out as they were in the dBA scale.

MR. TYLER expressed reluctance at being drawn into a discussion on heavier weights, because it was not his field and it was a very hot potato politically. He would say, despite the disagreement that he knew it would provoke, that - from his own experience - vehicles with heavier weights were not necessarily noisier and also current production vehicles,many of which could carry the suggested higher weights,were quieter than those of a decade ago. With regard to numbers, the calculations done at the Laboratory would indicate that the total number of heavy vehicles of that class would be fewer, because there was only a certain amount of material to be transported anyway; unless business significantly improved there was no reason why the number should increase by increasing the maximum permitted weight. Still, it was dangerous ground, and he had resolved before the meeting not to get involved in the subject!

Obviously, the cost to the manufacturers was going to be higher: his paper had mentioned a 7½% increase in initial cost for the QHV. But that, amortised over the working life of the vehicle, was really very small. There was a slight increase in weight, which in theory reduced payload, but only with fully laden vehicles. The fact remained that if quiet vehicles were wanted, particularly of the very heavy class, these were penalties which had to be tolerated. Who ultimately bore the cost was another matter: manufacturers, did, initially, the operators when they bought the vehicles, but ultimately, Mr. Tyler suspected, it would be the whole population, who would find marginal increases in the price of goods. He wished to emphasise, however, that the additional costs involved would appear to be very small indeed when compared with the other costs of transportation of goods, and he felt sure that most people would be prepared to pay a small incremental amount to obtain quieter vehicles.

The date, as already stated, depended on the EEC deliberations. Naturally, manufacturers were not going to build them until they had to; the world of transport was very competitive and quietness was not, generally speaking, something which could be sold (with the possible exception of cab noise, where the drivers' unions might insist on cab noise being reduced. But the manufacturers had already responded to that, because cab noise in current production vehicles was considerably less than it had been 8 - 10 years previously.)

On the question of low frequency noise, there were continual arguments for and against dB(A), dB(C), linear and other measures of noise. The fact was, as far as studies of nuisance - people's perception of lorry nuisance, including lorry noise - were concerned, the dB(A) measurements did correlate very well. Although it had been shown that vibration in buildings, particularly windows and ornaments rattling, was due to low frequency noise (air borne) emitted by heavy goods vehicles, this was not an argument for throwing aside dB(A). One had to accept that dB(A) was a very convenient unit to measure and correlated well with many other factors. It did exclude some low frequencies, and if that posed a problem then separate measurements using dB(C) or linear weighting networks, would have to be made. Mr. Tyler stressed that he would not like to see dB(A) thrown overboard for another weighting just because of the problems associated with low frequency noise. The two things should be measured separately.

MR. D.F. CORFIELD (City of London) wished to widen the discussion in a way. He said that there had been a vast amount of national and international research and experimentation done to enable prediction of annoyance, or the amount of noise that would stop people enjoying a reasonable night's sleep. He admitted to some cynicism in that respect, especially where building contractors were concerned, and therefore wanted to ask for Mr. Clough's comments on BS 5228, in that the levels he had mentioned as desirable at the boundary, of between 70 and 80 dB allowing for attenuation through a window, were still likely to cause a nuisance to the occupier, particularly in houses and in commercial office blocks.

In the City of London there was, as in other cities and towns, a rolling programme of building construction. The building contractor wanted to get on the site quickly, do his work quickly and get the hell out of it with the maximum amount of profit; similarly, the architect and the developer. With that rolling programme, he thought the stage would be reached where occupiers/ratepayers would suddenly come up with the idea that the local authority should do more to protect them. There was a precedent already in the 'Anns v. Merton LBC' case, which laid a duty of care on local authorities and had cost many local authorities a lot of money.

He thought local authorities should be looking to an extension intimated in recent publications of the EEC which referred to an increase and widening of the aspect of duty of care, to the involvement of planning and building contracts. Eventually, if one contractor continued to follow on another, the local authority might lay itself open to prosecution because it had not shown possibly the duty and care that it should have done.

Referring to the British Standard's suggestion of an Leq measurement over 8 or 12 hours,Mr. Corfield said that only at the end of that period of time was it possible to tell whether there was a nuisance or not. Therefore he, and his Authority, felt that it was far better to rely on the best practicable means. Thus, if somebody was not doing something right, they could be dealt with then and there; it was not necessary to wait until half past five or seven o'clock in the evening to find out whether the noise level could be measured or not.

MR. CLOUGH, referring to noise at night-time and the disturbance to people's sleep, wished to make it clear that a level of 70 or 80 dB from a construction site was totally unacceptable at night-time. That was a daytime level. In the best of all possible worlds, all noise levels from construction sites would be acceptable, but contractors were under a great deal of pressure from different sources, not just on the question of noise abatement.

The staff at Wimpey Labs. did their best to educate the contractors, site agents and subcontractors to minimise the noise, but such people were not in their employ. What paid the wages was the prompt and successful completion of the contract, showing as big a profit as possible. Such pressures would always exist despite their efforts to reduce noise as much as possible.

The limit suggested in the BS of 75 was not a legal limit, although it had been used as such. The guidance on limits had to come from outside the construction industry, which was going to work right up to whatever limit was set. Mr. Clough said that he would like to see the limits from all Wimpey construction sites as low as possible but the company did not look to Wimpey Laboratories to set limits. It looked to the local authority or to official guidance such as the British

Standard. The construction industry was not likely to reduce the limit of its own accord.

Mr. Clough agreed with Mr. Corfield that a BPM approach was much preferable to a limit approach, since it was not just the level of noise that caused annoyance, but the type of noise. It was a truism that "no noise is more annoying than that which could easily be avoided". If people could see that a noise was necessary, they were prepared to put up with it; lower levels of noise which were plainly unnecessary were going to give much greater annoyance. In addition, limits were difficult to measure and to agree on. For instance, Wimpey Labs.had measured the background level outside an office block in Westminster prior to some refurb. work being undertaken, and the ambient level was 70 - 72 dB(A) at the facade of the nearby buildings which were all tall blocks creating canyons which reflected and increased the traffic noise. In such a case there would have been a problem in setting a limit of 75 dB(A), because the level would vary according to the background which would be adding in to the site noise. So, the BPM approach was preferable.

MR. D.L. BARRY (Atkins R & D) explained that Atkins Environmental Consultancy had produced the draft code of practice (B.S. 5228), but he could not remember whether or not their recommendations on standards in the draft had actually got through to the final version.

He had given many talks, up to a couple of years before, to environmental health officers on construction noise standards and like Mr. Charnley had been very surprised at the non-event that construction noise problems turned out to be. He did not know why that was so; he assumed it was because people felt that the noise was transient, to a degree. The majority of construction site noise problems were of fairly short duration - highways were perhaps an exception although they were not, by definition, always concentrated in one location. However he felt that if people realised that they had recourse to action and knew what the powers of the local authority were, they might well complain more.

Returning to the principal theme, Mr. Barry thought Mr. Clough's point about communication was indeed fundamental but involved another aspect and that was the need for communication at the design stage. Mr. Clough had implied, of course, that he communicated with his engineering colleagues. The question of noise emissions could not be resolved simply by best practicable means. For instance, the less scrupulous tenderer could tender on the basis of using a particular type of construction and if there was no obvious noise constraint in the tender documents, problems could result because he could take the following line: "This is what I priced for; nobody said I could not use this sort of equipment. You can't say now that I should break the concrete for example by thermic lance rather than pneumatic drills. This will make the cost go up prohibitively".

On the other hand, great care had to be taken not to interfere too much with the expertise which contractors had in selecting the optimum (in both financial and practical terms) construction techniques. Therefore it was important that potential problem areas were identified at the design stage so that the more scrupulous tenderers were not competing unfairly with the less scrupulous ones, i.e. they were pricing for the 'same' job. Liaison at the design stage with engineering and planning colleagues certainly would help. Such liaison could also allow the use of another technique for controlling noise, e.g. if one had a choice in the way the building was orientated, it might be located on the site in such a way that the construction operations were screened by the building itself as it rose. That was a nice theoretical answer but these were the sort of considerations which might help particularly in some urban areas.

There was some irony in CIRIA's involvement in the subject since Mr. Barry's work with them recently had involved a lot of meetings at their offices, and without question it was the noisiest construction site that he had ever experienced; there was literally a canyon next door and no way that they could reduce the noise source.

75 dBA Leq (12 hr) had never been intended to be a standard, merely a maximum desirable. If his memory was correct, Wilson's references to the 75 dBA standard had been with the window shut. Mr. Barry expected that most people would like to have the windows open in the summer, so one might say that the '75' should be '65' during that period, i.e. there was a 'loss' of 10 dB(A) attenuation. So he thought that 75, even though it had never been intended to be a standard, was not perhaps even relecting Wilson's recommendation.

MR. CLOUGH, taking up the first point about the lack of complaints about construction site noise, agreed that this was owing to its temporary nature. People were prepared to put up with a noise if they knew it was going to go away.

He fully agreed with the comments about including noise control at the design stage. Wimpey's usual procedure was to come to the Lab.if they had a problem, wanting a solution. The Lab.would,in fact, prefer to deal with tenders such as road jobs because nearly all road construction jobs had the noise specification in the contract. The noise specification would be sent with a copy of the trace and a list of the intended methods of working; the Lab. would then measure the distance to the nearest dwelling and decide whether limits were to be made, what different types of plant could be used, where barriers would be necessary, which bunds to put up first etc. This was clearly a much better way of working and Mr. Clough would support any move to ensure that all tenders included a noise control specification, which lay down a limit and showed how the contractor was going to meet it. Such a system would also be fairer, since everybody would have to take noise control measures into account at the tender stage.

The point about the design of tall buildings was a good one; however, Wimpey had found that the tall buildings were often surrounded by other tall buildings, so that the offices therein had a perfect view straight down on the construction. The fall off with distance was reduced as the levels of the new construction rose because there was no ground effect and no partial shielding effect from plant/parts.

Mr. Clough then clarified what Wilson had said by quoting him directly: "These levels must be practicable and fair for the construction and demolition industries and we therefore suggest that at present noise levels outside the nearest building at the window of the occupied room closest to the site boundary should not exceed" - the limit was given. Admittedly, Wilson had said "at present" - that was 1963 - but those were his actual words.

CLLR. L. HARRISON (Wakefield MDC) wished to stress the importance of the community in a consideration of noise, particularly with regard to heavy lorries. Heavy lorries were needed, but had to be made compatible with the community. His own village was habitually disturbed in the early hours of the morning by heavy lorries on inadequate and badly maintained roads - those were not the sort of roads on which heavy lorry research was conducted. More research was needed in order to minimise the impact of pot-holes and improve linkage and coupling materials.

In addition, noise insulation grants were not available to householders when the nature of road traffic altered, only if the road itself were altered.

Site noise was also a problem in the village. The pit's tannoy system was loud enough to summon every inhabitant and the automatic winding gear whistled all night. It was a permanent site, but no amount of complaint had produced any improvement in the noise level.

MR. D.V. RANDON (National Coal Board, North Yorkshire Area) said that following the comments of the previous speaker, he hardly dared declare himself to be Environmental Officer with the National Coal Board!

He wished first to endorse the comments made on public relations, which he believed to be an absolutely essential element of successful operations. The Board had found that if the effort was made to tell people what was being done in the important phases of the construction work on the Selby Coalfield Project, to involve local people in that way, then there were usually few problems.

Following on from that was the relationship with the Local Authority Environmental Health Officers. His own preference was to avoid resorting to the formal use of the Control of Pollution Act, but rather to make informal agreements based upon it.

Linking in with that was the related point on piling operations, mentioned earlier by Mr. Clough. The NCB operated its own Code of Practice for piling on the Selby project: the important facts to be borne in mind were the noise/vibration levels, costs of various piling options, the type of ground, the timing of the pile driving and the distance from the nearest properties. Again, he discussed the proposals with the Local Authority Officer in advance of the work being undertaken, asked him along to see the type of plant, especially if he had not seen it before, and then invited his comments. They then informally agreed on the most appropriate method; in other words, they adopted the "best practicable means". He was pleased to state that NCB had been able to carry out all imaginable types of piling, including some during the night period, without any serious problems. Again, there was strong emphasis on the public relations aspects.

He had two small points to make on the use of barriers.

The NCB used them extensively, especially on surface borehole sites, and one very essential requirement was that there should be no gaps between the individual screening elements of the barrier. Some difficulties had been experienced in the past with structural stability and he had noticed on Mr. Clough's drawing that raker legs had only been shown on one side. NCB had found them to be necessary on both sides in exposed situations, otherwise the wind might come along and destroy the lot.

Finally, he wanted to link what had been said on construction noise with what Mr. Ankers had said that morning. On the Selby Project NCB had been placed in the unfortunate position of having a Section 52 planning condition imposed for the construction phase, and had found it to be largely irrelevant. In the event both the Local Authority Officers and NCB had had to ignore it. What they had done was to employ the "best practicable means" of noise control and that was despite the fact that the construction work at each Mine site was spread over several years. In fact the situation was an exception to the rule, mentioned earlier by Mr. Clough, of construction noise at a particular location being fairly short term.

When it came to the permanent operational situation, then he agreed that there should be planning conditions, but he made a plea for realistic ones, that could be worked to:- the appropriate noise levels at the appropriate distances for the particular operations, whereby the impact on people at various distances from the works could be minimised without wasting resources on unnecessary noise control.

MR. CLOUGH expressed agreement with the point made on noise from mines. Having sat near a coal pit in the middle of the night measuring the environmental noise from it, he had been amazed to find that the noisiest thing was the tannoy, which had also transmitted some amazing language.

On the question of piling, he had found that when piling took place near to private houses people were often prepared to put up with the noise but they were very concerned about the vibration and its possible effect i.e. permanent damage to their buildings. That was an entirely different subject but it was covered by the Control of Pollution Act which stated that it should also refer to vibration.

As far as the barrier was concerned, Mr. Clough agreed that all the gaps should be sealed and an appropriate barrier chosen for the weather conditions. Wimpey had designed a noise barrier made of timber at a quarry in Scotland , which had been ridiculed by the clients who had it redesigned in concrete blocks. After about two weeks it had blown away. So it was essential to construct a barrier appropirate for the situation.

MR. A.J. CLARKE (CEGB), wished to make a point on behalf of Urban Residents Anonymous. He had been tempted to speak because of the earlier intervention by Mr. Corfield of the City of London, which was rather an unusual institution. It had a daytime population approaching 500,000 people and a night-time population of about 5,000 - i.e. 4,999 and Mr. Clarke himself.

The topic which Mr. Clarke wished to raise was that of communication, which was sometimes most evident by its absence. A few months previously he and his neighbours had been disturbed by a loud noise at about 8 o'clock one Saturday night. A very large engine had been revving up and down and it turned out that a giant mobile crane, easily capable of lifting a bundle of steel girders over the top of the 200 ft building, was being erected in one of the 'canyons' previously referred to. The other side of the canyon comprised the bedrooms of around 200 flats. A quiet conversation with the driver had disclosed that they had been given permission to work through to 8 o'clock in the morning, in order to get the crane erected. The workmen narrowly escaped a lynching, the police arrived and the operation was stopped at 12 o'clock. The noise, from what must have been a four or five hundred horse power diesel engine revving up in that canyon on a Saturday night, had been intolerable.

The episode demonstated a particular aspect of lack of communication; the police and the city environmental health officer had given permission and apparently even the Resident's Association had given permission. Nobody could blame the authorities for the fact that the one gentleman representing the residents whom they had contacted, and who had given his consent, had disappeared for the weekend to his country cottage, leaving the other residents with the problem!

It was natural in that kind of environment that operations which were going to disrupt traffic tended to be confined to the night or weekend; but what residents there were had to be considered. Since that episode, channels of communication had, in fact, much improved.

H. DAWSON (Chairman) thanked Mr. Clarke for reinforcing the message of communication and the speakers, John Tyler and Richard Clough, for their excellent contribution. He referred to Schopenhauer, the famous 17th Century German philosopher, who wrote, "The noise of the carter's whip murders all thought"; it was a salutory thought that that source of annoyance was now being replaced by other and much more horrific sources. It was about 100 years since John Clare, the Northamptonshire country poet, wrote that he was "lost in a troubled sea of scorn and noise"; that might well be how a lot of environmentalists felt. But Mr. Dawson thought that the concern expressed about communication and consultation would in fact rapidly change the situation, to encourage environmentalists, engineers, environmental health officers (that much-abused band) and politicians to work together through and outside the National Society for Clean Air to make the land pleasant, green and acceptably quiet.

THURSDAY 21 OCTOBER

MORNING
SESSION FIVE

AIR POLLUTION AND HEALTH: THE CHANGING SCENE
R.E. Waller, Principal Scientific Officer, Toxicology and Environmental Pollution Department, DHSS

A REVIEW OF POLLUTION IN BUILDINGS AND UNDERGROUND FACILITIES
Dr.M.F. Fox, Senior Lecturer, School of Chemistry, Leicester Polytechnic

COFFEE

FINDINGS OF THE EC BLOOD LEAD SURVEY
M.J. Quinn, Environmental Protection Statistics and Economics Division, Department of the Environment

EFFECT OF AIR POLLUTANTS ON MATERIALS
Dr. K.G. Saunders, Technology, Planning and Research Division, Central Electricity Generating Board

MR. M.J. GITTINS (Leeds City Council), opening the discussion, began with Mr. Waller's paper. Remarking on the growing tendency at NSCA conferences for the distinguished authors to write one paper and present a second, he said that Mr. Waller had certainly benefitted the audience by that two-pronged approach. The disadvantage of that technique was that the data given in the visual presentation was often without references. Hence, whilst Mr. Waller's paper made virtually no mention of lead, he had presented a number of slides and overlays which included information on that element in the data. He had also made his own assessments of the relative contributions of lead and of a number of other pollutants to human intake. Mr. Gittins said that he would welcome the inclusion of all those figures in the Part II proceedings of the conference (see pages 105-108).

Secondly, in the section on aldehydes in Mr. Waller's paper, which had not been mentioned in the presentation, there was an interesting comment (certainly one that would interest some local authorities). Recent publicity on formaldehyde emissions from cavity wall insulation had caused a vast amount of concern to some members of the public. The paper stated: "There is no evidence that exposure of the magnitude likely to occur among the general population has long-term effects". The most comprehensive review of the literature Mr. Gittins was aware of was the Health & Safety Executive publication produced by EMAS earlier in 1982. Having read that carefully Mr. Gittins concluded that there was no clear understanding of formaldehyde sensitivity. In fact, the evidence reported was contradictory. What concerned him about the written paper was the danger of people thinking that there was no evidence because there was no causal association. That type of word construction had been encountered before. What it had often meant in fact was that nobody had looked at the evidence on the way in which the effects were occurring.

Turning to the second paper of the session by Dr. Fox, Mr. Gittins said that many in the audience would be aware of the work carried out by Malcolm Fox and Ivor Barker. He had made a very important contribution to the understanding of problems associated with carbon monoxide in car parks. It was evident that local authorities should be aware of their responsibilities in that respect, not just in relation to clean air, but also in relation to health and safety. He asked whether Dr. Fox had any guidance to give on ventilation requirements. There was a clear need for vigilance at the planning stage if some of the worst problems, demonstrated in that morning's presentation, were to be avoided. His own Department in Leeds had been recommending for some years that car parks should achieve eight air changes per hour. Frequently, however, that requirement for adequate ventilation had not been achieved. Exhaust outlets were often blocked up, and measurements of ventilation using trace gases showed that ventilation requirements were not met, due to bad building design, even if the fans moved eight air volumes per hour. Rather than simply using warning signs, there had been a recent move towards the installation of CO detectors which turned fans on or off, to give better protection and to minimise energy consumption. He asked for Dr.Fox's comments on that development. Mention had also been made,in the paper and in the presentation, of indoor pollution levels, particularly of the Cleveland work. As he recalled, that particular study had involved a very small number of houses. He wondered if there was any work afoot to carry out similar studies on a larger population.

As he had mentioned earlier, Mr. Gittins felt that Mr. Waller had been rather dismissive of formaldehyde. Malcolm Fox certainly recognised the problem of short-term exposure; Mr. Gittins wondered what his views were on the more long-term effects?

The NSCA had recently called for further monitoring of roadside pollution, and felt that local authorities should be doing that work. The thinking behind this policy was that in urban streets subject to often heavy diesel traffic,levels of air pollution might fall outside the EC Directive on Smoke and SO_2. The Conference had drawn attention to problems of CO in car parks and local authorities should also become far more deeply involved in that type of work.

Commenting on Michael Quinn's paper,Mr. Gittins said that when the 1979 Blood Lead Survey had been carried out, the trigger level had been 35 ug/dl. At that time, his authority had used 30 ug/dl as the trigger. In the more recent DoE Circular, the trigger level had been reduced to 25 ug/dl. He asked whether Mr. Quinn had any information on the effects of the new lower limit on previous studies, if it was to be applied retrospectively, and whether he could indicate if and when the trigger level would again be reduced. The DoE Circular itself had been rather a non-event, with Marsham Street once more sitting on the fence. It indicated that lead was a problem in paint, for example. The children who were most exposed to lead in old paint lived in the inner cities, so were exposed not just to the paint, but often to lead from water pipes, urban traffic and many other sources. The problem local authorities appeared to be confronted with was that they could not take blood samples from those children, because of the ethical reasons lightly touched upon in Mr. Quinn's presentation. He asked whether Mr. Quinn could give any more information on the ethics of the matter, because it was of great concern, certainly to him.

Page 12 of Mr. Quinn's paper referred to seasonal variations in blood lead, and Mr. Gittins wondered what the basis of that reference was. Another question arising from his paper was the discussion on page 10, and in the presentation, on the variation of blood lead with ethnic groups. The situation seemed very confusing, and he wondered whether any more work would be done on that aspect, or whether it would again be restrained on the grounds of medical ethics.

Turning finally to Dr. Saunders' paper, Mr. Gittins asked if she could explain why so much corrosion work had been carried out on zinc; whether the purity of the element under study was a relevant variable in the equations which she was deriving. She had also referred in her paper to the Littlehampton survey, which intrigued Mr. Gittins. He asked whether she could give further details of that study: specifically whether the work was being carried out on an open site, or whether the various plots were enclosed. He asked how she partitioned out all the other variables eg. crop production, damage of insects, soil condition, moisture, and the many other things which would also govern the way in which crops grew.

Finally, when she had introduced her proposals for a re-survey, she had referred to the 'extended survey'. He wondered whether the CEGB saw the local authority having any role in that investigation. There was a vast number of sites throughout the country run by local authorities, where smoke and SO_2 were measured daily, using the National Survey method, and he wondered whether the CEGB felt that any part of its work would be extended to those sites.

In the few minutes available to the Discussion Opener it was very difficult to do more than just make a few passing references to key issues. Mr. Gittins thought that there was a danger in seeming to be over-critical, but that it was pointless to reiterate areas where there was general agreement between the Discussion Opener and the authors. Delegates had heard four excellent papers in the session and the authors had achieved a good balance between the technical information required by some delegates, and the more general approach required by others.

CLLR. J.C. BLEWITT (South Oxfordshire D.C.), referring to lead in petrol, said that after all the years which had elapsed since the issue was first debated, all the papers that had been produced, and the educational effort, the time had come when the case had been put, to be deliberated and to be passed. When the issue was examined in the light of miners' disease, or asbestosis, he felt that no further delays should be allowed. There had been ample time for those who object; it was after all the vested interests that had really dilly dallied to prevent lead-free petrol. It was an absurd situation when motor manufacturers were producing cars to meet the requirements of other countries. He asked how British people could be so stupied and ignorant as to ignore the welfare of their own nation.

MR. D. WILSON (CLEAR, Individual Member of NSCA) said that screening was only useful if the results were being compared with genuine levels of risk. It could not be too strongly emphasised that the reference levels for the survey reviewed by Mr. Quinn had no medical or scientific basis whatsoever and had been abandoned by many leading authorities including the British government, which had recently changed to 25 micrograms per decilitre.

As the British Medical Association had said recently, "For operational and regulatory purposes it may be desirable to set levels or zones of lead considered unacceptable or dangerous but there is little justification for such a classification on biological or toxicological grounds". A major document,published in Brussels (October 28 1982) by EEB and BEUC, stated that "The observed effects suggest that adverse behavioural effects may occur at blood lead levels previously thought of as safe". The document revealed the lack of any scientific basis for the current EEC directive on biological screening for lead and its selection of reference levels.

The Yule and Lansdown study in Greenwich had shown a 7 point IQ deficit at a level of 13 ug/dl; if that figure of 13 was set against the EEC study, an entirely different result would be obtained than the one which had enabled DOE ministers to say that it presented no cause for alarm. If the Otto research in America,showing brain wave effects at a level of 5 and 7 ug/dl, were put in the computer against those EEC figures, again an entirely different result would be obtained. In other words what was relevant was not the figures mentioned that morning, but the level at which damage occurred. The reference levels had been set at a sufficiently high level to guarantee that there would appear to be no problem. Furthermore, the surveys had concentrated far too much on adults when the real and fundamental problem was children. It was particularly significant that for the whole of the United Kingdom, the number of children in the study near major roads was 49; that simply would not do as the basis for any kind of policy making.

Mr. Wilson particularly resented the way the DOE always put a slant on their findings. Delegates had heard that morning, for example, that children near lead smelters had considerably higher blood lead levels than children living near main roads. That was like giving one child a pint of beer and another child a pint of whisky and wondering why the child with a pint of beer had fallen down dead drunk and the child with the pint of whisky had fallen down dead. Of course children living near lead smelters would be more exposed than those living near main roads; no one would argue against that, so why make the point. It was not a relevant point except when used to gloss over the fundamental issue. The fundamental issue was that the figures established by the survey, set against realistic safety thresholds,revealed a cause for concern.Lead was a multi source problem, and Mr. Wilson thought that the NSCA's well balanced policy was the correct one. He warned against being led into complacency by the figures presented by Mr. Quinn.

MR. J.D. ALLEN (British Gas Corporation) commented on Dr. Fox's paper, and his reference to the Cleveland respiratory study, to clear up any possible misunderstanding. He said that the study had concentrated on an area where the effects were expected to be more serious, so it was not representative of the general population. Secondly, at no time following their measurements of NO_2 had Melia et.al.ever said that NO_2 was causally related to the health effects. Their evidence suggested that there was a small difference in children's health in homes with gas cookers compared to those with electric cookers. The reason for that difference was not clear, and there was doubt that NO_2 alone was the cause of that difference. As a correction, he pointed out that the reference to the Cleveland study's measurements of NO_2 in bedrooms should be not 40-169 parts per million (ppm) but parts per billion (ppb).

CLLR. M.T. HEYDEMAN (Reading B.C.) said that,in the matter of the car parks, much of the problem appeared to be due to long queueing at busy times. In Reading, they had recently changed over from the queueing system to a pay and display system, and contrary to the fears of some councillors that the authority would lose a lot of revenue, motorists in fact preferred to use the car parks now because they could get out quickly. He was sure that there were also implications for health - there was no long queueing, there was no delay, there was no build-up of carbon monoxide, presumably, although he had to admit that they had not been monitoring it hitherto. He thought that was something they should do and which ought to be considered.

Cllr. Heydeman had three questions for Mr. Quinn. First, when he had strange, non-normal statistics, Mr. Quinn, as a statistician, probably found it convenient to normalise them. As a biochemist, Cllr. Heydeman was very suspicious of the transformed data, and wanted to know why Mr. Quinn had not gone over to non-parametric measures. For example, he could have quoted the top decile,that concentration of lead which was exceeded by 10% of the sample. That would have been far more meaningful as it would have indicated that level of the population which was most at risk. Whereas a mean of whatever kind, was really just cloaking the problem. Secondly, he asked whether a correlation had been sought between the higher lead in males, and the fact that males tended to go into an environment where there was a lot more lead. Some men worked in city centres, some men had to travel the roads: and everyone knew that the roads were the sources of airborne lead pollution.

Thirdly, he asked whether Mr. Quinn was aware, whether everyone was aware, that pollutants interacted. When a smoker smoked, he narcotised - he dulled - the little hairs - the cilia in the bronchi. So if he inhaled particulate lead, instead of that lead being wafted gently up the bronchi, and out into the alimentary canal, which was effectively outside the body, it stayed, gradually dissolved and was taken in. Whereas the non-smoker who took in particulate lead got rid of it, the smoker would tend not to. So the smoker was not just taking in lead from tobacco, he was taking in more lead from the atmosphere, which of course came from lead in petrol - he knew DOE did not like that point, but it was one of those facts.

Alcohol caused an immense shift in metabolism; there was a change in blood uric acid and in lactic acid and alteration in liver function. He asked whether Mr. Quinn was aware of any study being done on the interaction between that shift and lead metabolism, because he was quite sure that that would also be found to be a significant factors.

CLLR. N. TAGGART (Leeds City Council) referred to Mr. Quinn's remarks about the particular problem faced by some Asian Children, and his comment that relatively few children had been included in the 1981 survey "for obvious reasons". Cllr. Taggart asked what the "obvious reasons" were. His second question related to the 1979 survey. In Leeds, in particular, it had covered two areas of the city, one inner and one outer-city. The inner city area, Harehills, had the biggest Asian population of any single part of the City of Leeds. Cllr. Taggart asked what proportion of the sample had actually been Asian.

His third point was perhaps more of a suggestion. Referring to Figure 5, in Mr. Quinn's printed paper, Cllr. Taggart said that he realised that at the time of the survey, the offcial DHSS breach stage had been 35 μg/dl. He asked whether it would be possible for Mr. Quinn to update Fig. 5 and the relevant overhead, to include also a column which would show the effect of the new level of 25 μg/dl. Whatever people's opinions were as to whether the trigger should be lower than 25, he felt that a column showing the percentage of children who would be over the breach if the 25 formula was applied would be much higher and much more significant in cities such as Glasgow, Leeds, Ayr.

MR. S.J. GARROD (Oxford City Council) had two points, one in connection with passive smoking, the other one in connection with the body lead burden.

The first two speakers had made reference to passive smoking and the adverse effects it could have on health. He wondered whether more attention should now be paid to the subject, and perhaps more research carried out. After all, great efforts had been made to encourage people to stop smoking; perhaps more publicity should be given to the adverse effects that passive smoking could have on people. It seemed to him to be another, different approach, to which some thought should perhaps be given.

With regard to Mr. Quinn's paper, the point had been made that perhaps the reference levels might be lowered in the not too distant future. He wondered, therefore, whether more research should be carried out, and said that if the reference levels were reduced, something should be done about the recent DOE Circular on Lead in the Environment. That particular circular told local authorities that they should be doing further monitoring work, that they should look at lead in water and lead in paint. But there was one glaring omission: there was no finance available to local government for this particular exercise. He asked whether Mr. Quinn agreed that if the Government was really seriously committed to doing something more about lowering the body lead burden, it should be providing some funds for local government to try and carry out the monitoring programme.

DAVID BARRY (Atkins R & D) had a question on Dr. Saunders' paper. As he understood it, wetting and drying cycles were fundamental to corrosion, and he wondered whether or not in her assessment the 'time of wetness' might be an oversimplification in that 100 'continuous' wet days might be less significant than 100 wet days interspersed with 100 dry days.

MR. R.I. KEY (Worcester City Council) referred to the general lack of survey data in respect of lead levels in school children. He confessed that his authority had not been aware of the ethical reservations expressed by the BMA on the subject of sampling children's blood lead levels. Whether or not they should have done so, he and his colleagues in Worcester had recently sought and gained the very ready consent of the parents of a local primary school, and with the co-operation of the Area Health Authority, had undertaken a survey of the blood lead levels in the school children. Those results had been passed to the Department of the Environment, and it might well be a useful suggestion that if any other local authority had undertaken a similar survey, they should forward the results to the Department of the Environment in view of the obvious gap in knowledge on that point.

MR. I. BARKER (Sheffield City Council) said that a criticism often levelled at the Clean Air Conference was that the subject matter was often of a highly technical and esoteric nature and that delegates drawn from members of local councils had difficulty in relating to it. Two of the topics discussed that morning by Dr. Fox and Mr. Waller, which related to the generation of toxic gases in the domestic situation, had a great potential, he felt, for being lifted out of the abstract and placed very violently into the political arena. It required only one headline in a local paper saying,"poison gases found in council house kitchens",to create a highly intensive political situation to which politicians had to respond quickly and politically. In such a situation they needed objective advice. Following up Mike Gittins'point, Mr. Barker said that when it came to providing advice,very often there was a lack of objective standards against which officers could provide a perspective between the measured levels of gases that had been found and their significance for the domestic situation or the community response.

MR. D. BIRD (Sheffield City) had a question on the monitoring of SO_2, which Sheffield were currently undertaking from a point source in a hospital. The high levels of SO_2 which they were monitoring were leading to corrosion damage and he wished to ask if the formulae were sufficiently well advanced at that time to be able to predict the rate of corrosion damage from a point source such as a chimney.

The peak level that they had measured was somewhere in the region of 1,500 $\mu g/m^3$ over a 24 hour monitoring period which was approximately $\frac{1}{3}$rd TLV. As Dr. Fox had said, they were not dealing with a healthy population; in hospitals people were clearly vulnerable. Did the panel know of any work which dealt with the thorny problem of TLVs and disadvantaged populations?

MR. M.J. QUINN (Author) said that before replying to the points raised by Mr. Gittins, he wanted to thank the Chairman, Mick Archer, for his work in that field; and also to thank Mr. Gittins for his work in Leeds where a tremendous amount had been done on blood lead monitoring. The first of Mr. Gittins' points had related to the trigger, and what would be the effects of the new lower limit. Mr. Quinn felt that he could clear up several points in one go on the reference levels. He had heard it said that the reference levels had been set after the results of the surveys were known. In fact, the way the reference levels had been set was that in 1976-7, a small group of experts within the European Commission, independent of any government, had looked through the literature then available; at that time, as he had mentioned in his paper, there had been no large scale population studies either in Europe or America. Everything before then had been very small scale, using different methods of blood lead measurement and different ways of taking blood.

Based on the knowledge available at that time and in consultation with health experts in the World Health Organisation and others, it has been decided that surveys of people not exposed to lead in the course of their work should fit within the reference levels then specified. The highest reference level had been 35 μg/dl, and the other two levels had been intended to specify the shape of the rest of the blood lead distribution. He did not think that he had made it quite clear in his paper that in fact at the time of the first blood lead survey the current advice from the DHSS had been to follow up children if their blood lead level exceeded 30 μg/dl; therefore the advice at the time from DHSS had already been in advance of those reference levels.

On seasonal variations, very scant information had been available before those large scale studies; the available information had tended to indicate that possibly levels were higher in summer and lower in winter. So it had been decided that sampling ought to be carried out over a relatively short period. To a large extent, that had been achieved. Samples had been taken in the spring of 1979 and in 1981. Quite detailed statistical analysis of the first survey had been carried out (the analysis of the second survey was still underway) and indications were that there were only very small seasonal effects: samples had only been taken over a three month period, and the seasonal effect over that short time had been relatively small.

Mr. Gittins and several other speakers had mentioned the problems of taking blood from children. There were obviously wide local variations as to whether ethical committees would allow blood lead surveys to be carried out. In some areas, for example in Hillingdon, some surveys had been allowed to take place, but not with venous sampling, as that had been considered to be an assault on the child. Only capillary samples had been permitted.

Mr. Gittins and another speaker had mentioned ethnic groups. Mr. Quinn said that the reason that not many people of non-white origin had been included in the survey was that there were not many people of non-white origin in the UK. One speaker had raised the question of the proportion (of Asians) in Leeds in 1979; Mr. Quinn regretted his inability to answer, since the question (of ethnic origin) had only been added to the form in 1981. Therefore, there was no way of telling, unless those who had run the survey could go back to the medical records and look up the names and addresses, which DOE certainly did not have. It might be possible to get an indication, simply by the surname, of whether the people had been Asian or not.

Turning to Cllr. Heydeman's question about the statistical transformation, Mr. Quinn said that it certainly had not been intended to confuse. It was a standard procedure and was common in the literature. The distributions in virtually every population sampled had been found to be what was called 'lognormal', i.e., they were skewed with a long tail to the right. If arithmetic average alone was taken, it could be heavily distorted by one or two high values. In order to enable the normal statistical procedures to be followed, in calculating averages, standard deviations and so on, the blood lead levels were usually transformed by taking the logarithms, doing the calculations, and then taking the antilogarithms at the end. That provided a much sounder basis for comparing levels between surveys. The problem with non-parametric statistics was that once a non-parametric statistic had been derived, not much more could be done with it; averages could be combined, and so on, however, it was very difficult to do anything with medians (although in the paper he had attempted to do that, for the EEC comparisons). He felt that he should mention that the median of the log normal distribution was close to the geometric mean; they were pretty well equivalent.

He regretted that there was no information at all about the total exposure of men to lead and their environment. The surveys had included a questionnaire on personal habits, and an estimate of the age of the house; however, he thought that to acquire the amount of data necessary would require a diary, or something similar; it was very difficult to do even for dietary studies, where people prepared duplicates of their diet. It was quite a complicated procedure and it would be very difficult indeed to correlate blood lead levels with a person's environmental exposure to lead.

On smoking and alcohol, he referred the questioner to a paper in the BMJ on the Regional Heart Study, an excellent paper by Professor Shaper and Stuart Pocock at the Royal Free Hospital. That went into more detail, because the categories of smoking had been much more finely divided than in the biological screening surveys; the drinking categories had also been more finely divided. That study had concentrated on middle-aged men, and had shown that the increased levels of blood lead due to smoking were pretty much the same as found in DOE's survey, that the effect of drinking could be twice as much - and that the effects were cumulative. The effect of alcohol was not really understood, but there was a very good discussion in that paper. Mr. Quinn said that he personally had no medical qualifications, therefore he could not comment on the medical aspects of the paper. But as it appeared that there was no, or very little, lead in beer, it might well be some sort of biological effect.

Mr. Quinn was unable to comment on the question of finance for more monitoring. He was essentially involved in collecting the results of the surveys, analysing them and presenting them. However, he said that he would certainly take the message back to those who controlled the purse strings. He agreed with Mr. Archer that the results from Worcester had been very interesting, and said that should any other local authority carry out a blood lead survey, on schoolchildren particularly, DOE would be very interested to see the results.

MR. R.E. WALLER, replying, said that he took the point that Mr. Gittins had made. The diagrams he had used in the presentation would be included in Part II of the Proceedings; they were really an adjunct to the question raised in the paper, that certain pollutants, notably carbon monoxide (Fig 1) and oxides of nitrogen (Fig. 2), were common to traffic emissions and indoor sources, and illustrated the relative importance of the different sources. Mr. Waller had not initially included much on lead in his paper since he knew that it would be dealt with by Mr. Quinn; however, he had considered it useful to include in the presentation the diagram showing the relative importance of different sources (Fig. 3).

Mr. Gittins and other speakers had raised the question of formaldehyde. Mr. Waller said that perhaps he had seemed a bit dismissive of the topic, in that he had not been able to deal in depth with all the various pollutants that had been raised in the indoor context.

Undoubtedly there was a wide range of sensitivity to formaldehyde, and there were some people who were especially sensitive, responding with acute effects such as running eyes and throat irritation sooner than others and at lower concentrations. That alone was sufficient to indicate that some remedial action was required and if, for example, the source of the formaldehyde was chipboard furniture then the persons affected might be able to deal with the problem fairly easily, at least within their own homes. DHSS had no evidence of any long-term effects; as mentioned in the paper, information on the topic was being sought among people who had had relatively high exposures in their occupation.

Mr. Barker had sought further advice on questions such as adverse effects of oxides of nitrogen from cooking sources in the home. Mr. Waller wished to reassure him that there were certainly no alarming effects and the problem was to carry out studies on a large enough scale to be able to assess whether small differences in the occurrence of respiratory illnesses in children could be related specifically to oxides of nitrogen, or whether they reflected other differences in environmental conditions in the home.

There was of course the separate problem of poisoning by carbon monoxide in the home, as the result of a blocked flue serving a fire or boiler. As mentioned in the paper, it led to an appreciable number of deaths each year throughout the country. The risk of serious consequences from accidental blockages had increased as a result of reduced ventilation in homes. Mr. Waller thought that wide publicity ought to be accorded to the potential hazards.

The question of passive smoking had been raised several times; Mr. Waller said that he and his colleagues at DHSS were certainly very interested in that question, particularly in the irritation that smokers could cause to non smokers within poorly ventilated rooms and other confined spaces.

Again, those effects were seen mainly in terms of irritation to the eyes and throat, and some people were more sensitive than others. Whether there were long term effects, such as enhanced lung cancer among people who were constantly in the company of smokers, was more dubious and that question required further investigation.

DR. K.G. SAUNDERS, replying, started with Mr. Gittins' question about the reason for so much corrosion work having been done on zinc. She reminded delegates that zinc was used in a large number of applications. Steel was not exposed to the atmosphere without coating it with some protective layer, either by painting it or in many cases by actually coating it with zinc - galvanizing it. Galvanized steel was used, for example, in transmission towers which were of particular interest to the CEGB, farmers used galvanised wire fences, and there were constructions with galvanised sections, etc. Zinc was that a very widely used material. Therefore, it had been widely studied because of its economic importance. The zinc corrosion map by Mr. Shaw was being used by the Ministry of Agriculture to calculate the compensation for farmers for galvanised wire fencing. It could thus be seen that there were quite serious practical applications of that type of work.

Dr. Saunders agreed that the purity of zinc obviously would have an effect. Most of the work which had been done and reported in the literature was on pure zinc. There were some small variations to that but generally when corrosion rates were compared there did not appear to be much difference. It had not been quantitatively investigated but people were nevertheless aware that there could be an effect.

Turning to Mr. Gittins' point about the Littlehampton survey, Dr. Saunders explained that the project was originally a crop fumigation experiment; she had some details although they were by no means complete. It was an open field experiment, and a much more realistic and controlled kind of crop fumigation experiment than had ever been done before. Different year crops were being studied, barley or wheat, at 4 plots within the field fumigated to different SO_2 levels. Care had been taken to ensure that the fumigation gave a constant SO_2 level above the crop canopy height. Different types of measurements were being made, for example, respiration measurements on the plants. Measurements of the crop yields were made and account was taken of the many factors affecting that yield. She could assure Mr. Gittins that the workers were aware of the many problems involved in that type of project. The corrosion survey at the Littlehampton Site comprised the exposure of a range of materials at each of the 4 fumigation plots with additional measurement of SO_2 levels and surface wetness time for correlation of corrosion rates with climatic and pollutant variables.

Mr. Gittins'other question was on a matter of great importance to Dr. Saunders, the extended survey. The extended survey would cover the whole of the UK and hopefully provide enough data for some functions associated with other materials like paint and stone to be derived. Under those conditions local authority EHOs had a role to play, and Dr. Saunders expressed great interest, since the project was still in the planning stage, in hearing from anyone who had a monitoring site where there was space to expose some corrosion specimens, and where there was some security associated with the site so that could not be simply destroyed by vandals. As a bonus, a power supply associated with the site would be particularly welcome because wetness meter measurements were made wherever possible.

Turning to the question of corrosion in terms of a wet/dry cycle or a permanently wet cycle, she said that it was a complex matter, depending on the material and its application. The chances were that continously wet would be very bad, in that, certainly for zinc, it never actually formed a very good protective film if it was totally wet.

It formed an extremely porous film and therefore the surface was not protected and the zinc corroded at a very high rate. Wet/dry was the normal cycle and it had been shown that as a material dried, then the concentration of pollutants on the surface concentrated up and the corrosion rate increased. Therefore, for a brief spell a very high corrosion rate obtained; nevertheless, no corrosion actually occurred when zinc was dry: for zinc, continously wet was bad. As far as the equations were concerned, she and her co-workers were reasonably confident about their Dose Response equation. Reference had been made to a point source. Dr. Saunders said that it would be necessary actually to measure the SO_2 concentration wherever corrosion was occurring, or in the general area, to give a fairly reasonable estimate of what sort of corrosion rate could be expected, certainly on zinc.

DR. M.F. FOX, replying to Mr. Gittins' point on the ventilation of car parks, said that most car parks did not require ventilation. It was just the odd few that might show the need to be ventilated at certain times. It was completely unreasonable to ask somebody to go to the capital expenditure and the running costs of having something like eight air changes per hour. Therefore, he suggested that if there were problems in a car park, it would be better to explore other solutions such as pay and display which got people out very quickly when they wanted to leave. The traffic exit arrangements should be altered, and if there was still a problem, then he suggested the installation of fans operated by CO detectors. It was not necessary to use a non-dispersive infra red type, as it was an expensive device. There were inexpensive CO detectors working at the ppm level which could be used for continuous operation. Signs were basically a waste of time; with low level ceiling heights they were not generally visible when erected; when people did see them, they did not take any notice.

Dr. Fox said that the long-term effects of formaldehyde were known on the industrial hygiene side; one could go to the literature for information. With foam insulation he thought that the key was proper mixing. Having seen his own house done, it seemed to be an operation well suited to 'cowboys'. Starting from the premise that formaldehyde coming from foam insulation was due to an excess of unreacted formaldehyde being there in the first place, from improper mixing, reduction of the incidence of formaldehyde as a residual air pollutant could be secured by the introduction of some sort of control, or by going after those who particularly seemed to put in too much formaldehyde in combination with a defective inner leaf in the construction. The concentration of formaldehyde could be measured with a Draeger tube.

On the relationship between TLVs and air quality, i.e., transposing threshold Limit Values into standards for general population exposure, Dr. Fox advised approaching Warren Spring Laboratory, or, through WSL, the US Environmental Protection Agency. The US, and to a certain extent the European, philosophy of air pollution control differed considerably from the UK's. In the US in particular, the authorities had opted for air quality standards for general population exposure, using guidelines for both normal populations and disadvantaged groups, rather than TLVs.

Turning to NO_2 in houses, Dr. Fox first apologised for the mistake on page 10 of his paper (para 2, line 16); it should have been"40-169 ppb range" - if it had been ppm they would not have made it out of the bedroom! In the Cleveland survey the bedroom studies had been a sub-section of what had not been a very large study to begin with. There were many levels in that situation. Referring to the literature, he said that the Lutz and the US/EPA study had found no positive correlation, whereas Speizer had found a slightly different correlation. He felt that it was wrong to say there was nothing. There was something there, which could be put right by, say, better ventilation in the kitchen. When conversions from town gas to natural gas had been carried out, the regional boards of the Gas Corporation had gone round and looked at the ventilation of the houses, and the arrangements in the kitchen. With the amount of money they were making British Gas could afford to look at the possibility of providing sufficient ventilation in household areas which might seem at risk. Certainly, Melia had pointed out that if pollution from gas combustion was indeed harmful to health, then it could be simply dispelled. He did not think it should be a great problem about which it was worth getting into a confrontation.

LEGENDS TO FIGURES (See page 85)

Fig. 1 CARBON MONOXIDE SOURCES IN PERSPECTIVE. An indication of the relative importance of different sources (a) for the community at large, taking into account the population at risk, the concentrations and the times of exposure and (b) for the individual, indicating the response in terms of increased carboxyhaemoglobin levels for the more extreme circumstances (note, for example, that lethal levels can be reached in confined spaces, as in the last entry, but no otherwise).

Fig. 2 OXIDES OF NITROGEN SOURCES IN PERSPECTIVE. An indication of the relative importance of different sources (a) for the community at large and (b) for the individual. The emphasis is on NO_2, but because of the varying proportions of NO and NO_2, coupled with uncertainties about the relevance of exposures to peak as opposed to average concentrations, no more than rough guides can be given.

Fig. 3 LEAD SOURCES IN PERSPECTIVE. An indication of the relative importance of different sources (a) for the community at large and (b) for the individual, showing possible increments in blood lead values in the more extreme cases.

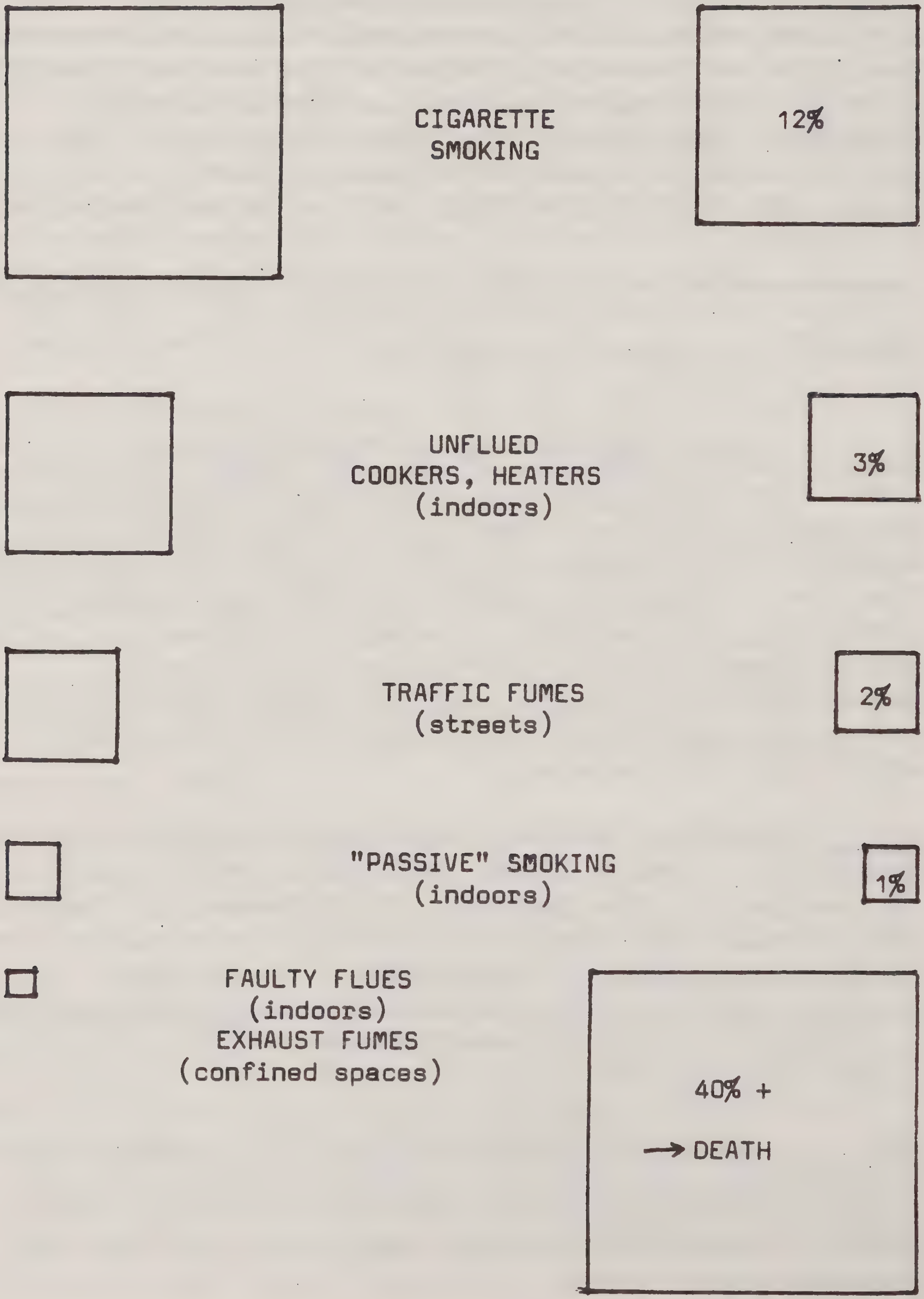


Figure 1

(a) COMMUNITY PROBLEM

(b) INDIVIDUAL PROBLEM (with carboxyhaemoglobin increments, % saturation, for the more extreme cases)

CIGARETTE SMOKING
12%
UNFLUED COOKERS, HEATERS (indoors)
3%
TRAFFIC FUMES (streets)
2%
"PASSIVE" SMOKING (indoors)
1%
FAULTY FLUES (indoors) EXHAUST FUMES (confined spaces)
40% +
→ DEATH

Figure 2

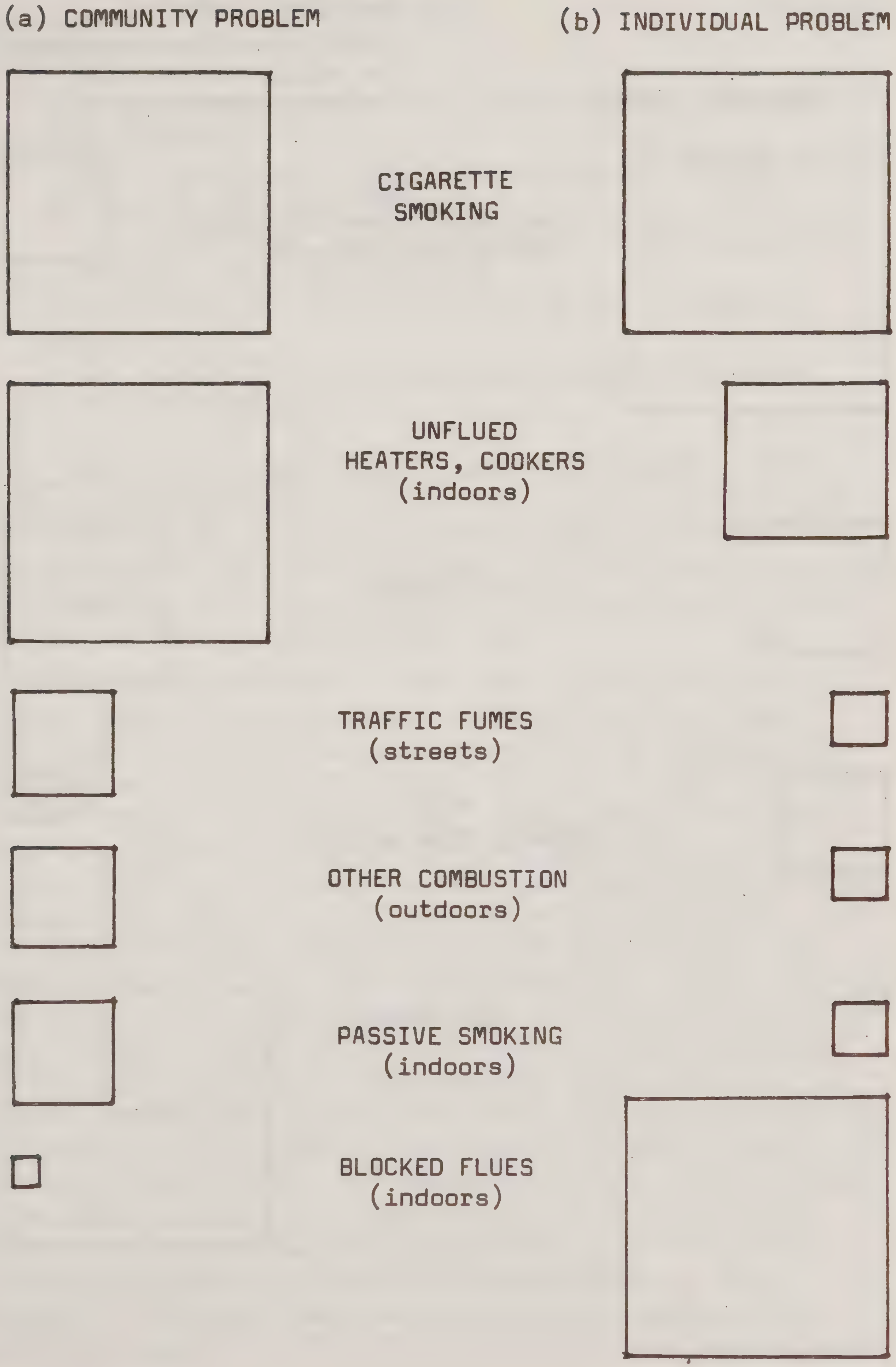
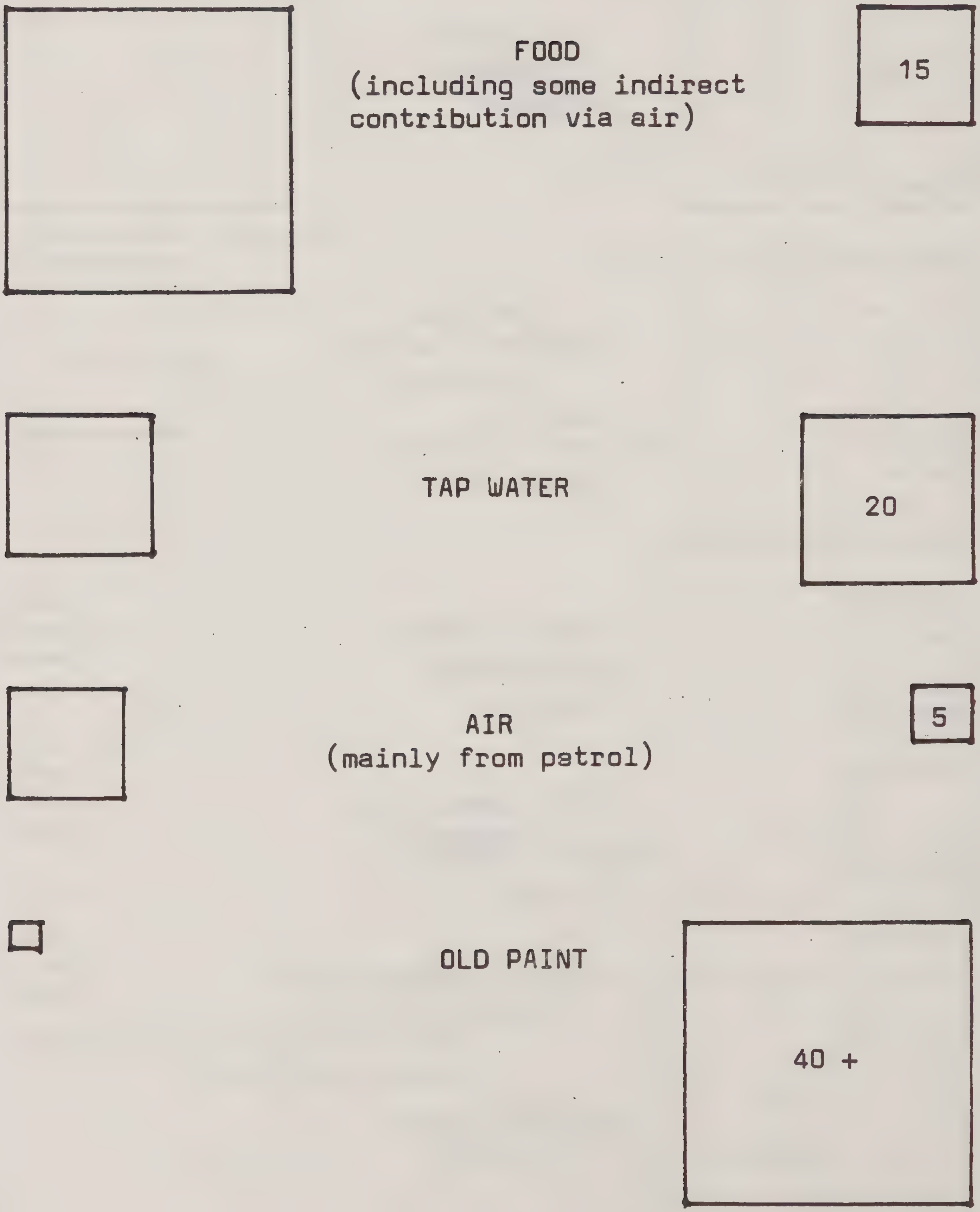

(a) COMMUNITY PROBLEM
(b) INDIVIDUAL PROBLEM
CIGARETTE SMOKING
UNFLUED HEATERS, COOKERS (indoors)
TRAFFIC FUMES (streets)
OTHER COMBUSTION (outdoors)
PASSIVE SMOKING (indoors)
BLOCKED FLUES (indoors)

Figure 3



(a) COMMUNITY PROBLEM

(b) INDIVIDUAL PROBLEM (with blood lead increments in ug/dl for the more extreme cases)

THURSDAY 21 OCTOBER

AFTERNOON
SESSION SIX

AIR POLLUTION CREATED BY AGRICULTURE - THE NEED FOR CONTROL

N.H. Parkinson, Chief Environmental Health & Housing Officer, Selby DC
J. Sidebottom, Deputy Director of Environmental Health, East Yorkshire BC

THE CONTROL OF AIR POLLUTION IN THE MINERALS INDUSTRY

Dr. A.F. Ellis, HM District Alkali Inspector, HSE, Manchester

CLLR. MRS. E.J. INGLEFIELD (Individual Member, NSCA), opening the discussion, said that it was difficult to link farming and quarrying, but farmers confined their muck spreading to the area round the farm while quarries operated more on the principle of throwing jelly into the fan so that everyone got a bit.

Dr. Ellis had referred to the area Mrs. Inglefield herself represented as a councillor, the High Peak. There was no other area in the country as intensively quarried as the Peak District. It was a place of high scenic beauty with tourism its other major industry, which was scarcely compatible with quarrying. The transportation of roadstone and ancillary products had a very wide impact on the environment, often more than the quarry itself, and gave rise to the majority of complaints about the quarrying industry. There were many complaints of lorries shedding dust and gravel; people simply could not understand why the management of the quarries did not ensure that only properly sheeted and secure loads left their quarries: insisting on sheeting up inside; or vehicles with mechanised sheeting being used. The Council wanted quarry owners to be more conscious of the impact of the industry outside the quarries and would have liked the Alkali Inspector to use his powers of persuasion in that respect. Lorries from the quarries were parked in small villages, and High Peak B C's housing department had had, at great expense, to erect bollards on Council estate car parks to prevent lorry parking because the noisy revving of diesel engines, referred to the previous day, at five o'clock in the morning, was a major irritant to all the residents.

Smoke from the kilns had been greatly reduced by a change to gas and oil firing, at great expense to the industry, and there had been a rise in standards but she wondered what would happen in the future, and asked Dr. Ellis whether there would be a change back to coal, and if so whether the new coal fired kilns would produce less pollution than their predecessors. High Peak BC's environmental health department had recorded a gradual reduction in the amount of dust emission measured with standard deposit gauges in the surrounding districts; Mrs. Inglefield said that she understood, however, that production had fallen considerably over the previous two or three years and it was running at 50 - 60% capacity. Therefore, how much that reduction was due to better control and how much to decreased production was not known. She wondered whether there would be an increase in dust emission if production were again to rise, and asked for Dr. Ellis's comments.

As a local Council, High Peak BC did not want problems to arise if and when producivity rose, because the industry was regarded as beneficial to the local community and to the nation. If the cost of implementing pollution control measures were to result in a rise in prices such as to render the quarries uncompetitive, the High Peak would be the eventual loser and therefore the effect upon unit costs and productivity had to be constrained within bearable bounds. In such times of financial austerity, with 3 million unemployed, there was a greater need than ever for the Alkali Inspector and Local Authorities to achieve the right compromise between costs and effectiveness.

There were new proposals to widen the Alkali Inspectors' control of quarries, removing some control from District authorities, with which High Peak BC did not disagree. It was considered preferable to have one air pollution control agency for one class of works; but that did not mean that the local authority was not competent to deal with quarries at district level. High Peak BC had a good relationship with both the Alkali Inspectorate and the quarries, and had a still wider role of monitoring air pollution; therefore the council looked forward to continuing a joint approach to the problem.

Turning to the paper by Mr. Parkinson and Mr. Sidebottom, Mrs. Inglefield endorsed the remarks about the rain gunning of effluent. She had been liberally sprayed several times in the previous weeks when driving past a local farm; not only had the car needed to be cleaned but every time she had put on the car heater she had received the perfume of the month - not Chanel,but Pig No. 5. It reminded her of Blaster Bates' talk entitled "A Shower of Shit Over Cheshire"!

One question had been handed to her by a delegate who had left the hall; it concerned the grazing of cattle on land treated with sewage sludge. In the RWA guidelines it was stated that farmers should not allow grazing for three weeks after sewage sludge had been sprayed, and research had shown that pathogens existed for up six months. Three weeks did appear to be inadequate, but even that period was not monitored. She asked for Mr. Parkinson's views on tackling the problem.

DR. A.F. ELLIS, replying, dealt first with Mrs. Inglefield's question on lime kilns and whether, if they changed back to coal, the emissions resulting from this change would be improved on those from their coal fired predecessors. Dr. Ellis thought that that undoubtedly would be the case. The "Best Practicable Means" requirements for lime kilns included a tight limit on the amount of smoke allowed, which had not been placed on their predecessors when they had been installed. The method of meeting these requirements would have to be considered and included in the design proposals discussed with the Alkali Inspectorate at the prior approval stage.

He had then been asked if an increase in production following the present recession would result in increased dust emissions from quarries. Dr. Ellis said that some dust emissions were closely related to production rates even when the correct control equipment was working properly. Nevertheless, a company operating a profitable activity was much better able to spend large sums of money on installing more modern pollution control equipment, so that in the long run the net effect of increased production could be a reduction in dust levels.

MR. N.H. PARKINSON, answering points made by Mrs. Inglefield, first expressed his thanks for her support of the ban on the use of the rain gun, which he felt was obviously long overdue. Its use had been on the increase in Yorkshire and Humberside, chiefly by the Water Authority of that region, and after strong representations from the eight District Councils in North Yorkshire, the Water Authority had agreed to a ban on the rain gunning of human sludge within that County. Unfortunately, the Water Authority was not prepared to give that assurance in respect of the remaining Counties of Yorkshire and Humberside.

With regard to the grazing period, a great deal of debate had gone on for a number of years; at the time it was difficult to say other than what the DoE were saying in their working party report, that the non grazing period should not be less than six months. The Water Authorities did not agree with that in general terms, nor did some of the farming community. Nevertheless, although acknowledging that a great deal more work should be done on research, he believed that the DoE recommendation should be adhered to meanwhile. Whether that period of time would be reduced when further work had been done remained to be seen. On a related point of interest, he said that the Yorkshire Water Authority had always claimed that there was a reduction in the amount of salmonella left in the sludge following digestion of even a few days but recent experiments in the Yorkshire area tended to disprove the claim; it appeared that the salmonella level actually increased in the raw or digested sludge.

CLLR. J.L. BLEWITT (South Oxfordshire District Council) said that it gave him great pleasure to speak, following the discussion at the 1981 Brighton Conference on stubble burning. He had been trying since 1968 to get to the point reached that day, and had found it very encouraging to see the photograph on display at the NSCA's stand, showing what stubble burning could be like for those who had experienced it. He felt that the Society had come a long way: it had taken time but, unfortunately, in spite of the progress made, it appeared that the Ministry of Agriculture, Fisheries and Food wanted to delay still further, and not act on the advice which the NSCA had put forward following the 1981 Conference.

Cllr. Blewitt said that it had been nice to see the National Farmers Union pressing for a stricter Code of Conduct. Nevertheless, he felt that the Code was not the answer,since however many bye-laws there were, and whatever the size of the fine, implementation was well nigh impossible because the intent to commit an offence had to be proved and evidence had to be given to support the case.

He felt that the answer to the problem lay in going still further, either to press for a total ban on stubble burning (a practice which was a disgrace to the Society and to clean air) or to ask the National Farmers Union whether they would be prepared to deal forcibly with any member infringing the Code (starting in 1983, because it was already too late for such measures in 1982):to expel if possible that member from the National Farmers Union and make him till the soil as farmers had used to do many years before. In his opinion, that was the only solution. Cllr. Blewitt said that no other industry emitting black smoke on the same scale would have been tolerated. Farmers had been allowed to do it because in the past farming had not been treated as an industry. The time had come, however when positive firm action had to be taken to protect the people for whom the smoke from straw and stubble burning was a great annoyance, and who were really affected by it. The protection of wild life and nature was another aspect of the problem. He asked delegates to make up their minds on the course of action to pursue, and hoped that MAFF in particular would decide one way or the other. Public health and the environment could not always be measured pounds, shillings and pence. Positive action was required and Cllr. Blewitt expressed the hope that it would come in the very near future.

MR. A.J. CLARKE (C.E.G.B.) shared the sentiments expressed by the previous speaker on stubble burning. He said that those who had attended the 1981 Conference in Brighton possibly rembered that in the discussion on stubble burning Dr. Kallend of the Central Electricity Research Laboratory (who had been talking on an entirely different subject) had mentioned being able to measure the SO_2 levels from stubble burning in an aircraft about 10,000 feet above the Midlands area. That had prompted Mr. Clarke to find out from his colleages in the Board, who had been making measurements in rural areas, whether there was any other evidence on the actual levels of the common pollutants, SO_2, NO_x particulates, caused by stubble burning. Some information had been gathered from CEGB Midlands area, where there was a network of rural gauge sites (maintained for an entirely different purpose). The Society had been provided with a certain amount of information by Mr. Alan Martin via Mr. Clarke, on what the actual levels were. Frequently, the SO_2 had been off scale when downwind of an area of stubble burning, which was quite a remarkable finding.

Mr. Clarke had recommended to the Society through its various Committees that some further investigation should be made, since it would strengthen the case against stubble burning if it could be shown through actual measurements that the levels contravened, for example, the EC Directive on SO_2 and particulates. Unfortunately it had not been possible in 1982, due to weather and the fact that the wind had been blowing in the wrong direction, to get any further readings in the Midlands area. However, Mr. Clarke suggested that any local authorities who had an interest in the matter might make a special effort during 1983 to obtain some actual measurements. It would make a considerable difference to the Society, enabling it to determine whether stubble burning should be tackled on the question of nuisance or whether the Society could actually point to some hazard from the levels of pollution being recorded. Mr. Clarke considered that a certain amount of effort would have to be devoted to getting instruments into the right places at the right times, possibly on a short term basis, but that if anybody could help the Society in that way it would certainly be greatly appreciated.

Turning to the Dr. Ellis's paper on quarrying, which Mr. Clarke said was not his field, he commented that all the quarries presumably had a good deal in the way of machinery and mobile plant associated with them. He wondered to what extent the emissions from the prime energy sources in those operations added to the pollution caused by the product itself, the dust from the quarry. He had been prompted to ask the question by the receipt only a week or so previously of a large report from the United States on the subject which they were pleased to call "comminution", the process of crushing, grinding or pulverising mineral materials to make them smaller. What had appalled him on studying the report had been the average energy efficiency of those rock crushing and similar processes, which was something like 1%. Thus, about 100 times as much energy was used in those processes as was actually required to crush the rocks. That necessarily meant that more diesel, or other fuel,was used.

MR. D.L. BARRY (Atkins R & D) referred to the final comment in the paper by Mr. Parkinson and Mr. Sidebotton, the quotation of the old scientific saying "if we cannot measure it, we cannot effectively control it". He realised that the quote had been used in the context of a paper about agricultural odour, but assumed that the authors would apply the saying to any odour problem from an industrial as well as an agricultural source. He believed that it was too pessimistic a view. His company's experience over many years was that odour could indeed be measured, though not as simply as noise, for example. If odour could not be measured, then it could not really be controlled other than by literally eliminating the source. If a farmer, or an industrialist, was to be asked to abate an odour nuisance then surely some indication had to be given of the level at which the odour was acceptable. There were techniques which were widely used for assessing acceptable levels of various odours and while there were not very many technical papers on the subject there was a lot of experience.

There were social survey techniques which would identify the levels of annoyance from different concentrations of odour; once that had been identified, it was possible to establish what levels of dilution were necessary to reduce the concentration to an acceptable level. Therefore, by relating the complaints to the meteorological conditions and the concentrations at source (which could be measured, albeit not always easily) the degree of control needed to abate the problem could be identified. He wondered whether or not the authors had any experience in using that approach. He appreciated there was a problem with non static sources but with fixed installations in particular he certainly felt that problems could be reduced or avoided even at the planning stage. Atkins had undertaken a study a couple of years previously involving a major waste disposal operator who wanted to get some indication of the potential problem to the neighbourhood before he extended his tipping area. Atkins had been asked to carry out an exercise which predicted the potential scale of problem. The difficulty lay in not knowing how accurate the predictions were but nonetheless good value judgements could be made based on data from social survey techniques, odour panels, etc. to establish a clear objective. Otherwise planning authorities might simply have to say "I'm sorry we cannot allow your smelly operation anywhere because sooner or later somebody is going to be affected". He asked the authors to describe their direct experience in the control of such nuisances.

MR. D. COLLIER (National Farmers' Union) wished to answer a couple of the points made on the subject of straw burning. First, Cllr. Blewitt had referred to the possibility of expulsion from the NFU. Mr. Collier emphasised that the NFU was a voluntary organisation rather than a closed shop, and expulsion was therefore not a practical sanction which could be used against its members.

Secondly, it has been suggested that provisions analagous to those in the Control of Pollution Act 1974, namely Sections 60 and 61 which dealt with construction site noise, should be used as a basis for measures to control straw burning. It was certainly an interesting idea; Section 60 allowed local authority, where they found that the relevant works (in that case construction and demolition) were going, or were about to be, carried out, to serve a notice setting out certain requirements. The notice might, for example, specify the plant or machinery which was or was not to be used. If the notice were, in the case of straw burning, to specify that the farmer would not be allowed to park his landrover in the middle of the field before setting the straw alight he was sure that the NFU would welcome it.

However, the NFU envisaged difficulties with the procedure based on the provisions in the 1974 Act. Some of the bye-laws governing straw burning specified that farmers wishing to burn straw should first notify the fire brigade. In a number of cases, however, the fire brigade specifically stated that they did not wish to be notified: their switchboards would be jammed during the few weeks of late summer when burning took place. Norfolk was a case in point. If the fire brigade could not cope with farmers simply phoning to let them know of a burn with brief details of its location, then quite frankly NFU doubted whether the District Councils' Environmental Health Departments throughout East Anglia and in many other parts of the country would be able to, first, determine whether the proposed fire would take place near houses and schools, hospitals, roads; secondly, discuss the restrictions which might be appropriate in any particular case; and, third, argue about whether the wind, perhaps measured a hundred miles away from the field in question, would affect the farm. Local authorities simply did not have the manpower to send an officer to every proposed fire and look at the individual case - which was what "proper consideration" could amount to. A council could hardly, either, draft in temporary workers for the short period during which the straw was burned. It was debatable whether their existing staff had the necessary expertise to decide in every case whether it was safe to burn.

There was no point in Environmental Health Officers calling for new legislation when local authorities had not made full use of the existing law. It was argued that bye-laws were not adequate, but the bye-law would remedy any problem which arose from failure to make a proper fire break. If it seemed that the bye-law needed to be changed the local authorities, perhaps through their associations, should persuade the Home Office to change the model. The increase in the number of prosecutions in one county alone demonstrated, in NFU's view, that the bye-law was fit for the task if the District Councils were prepared first to adopt it and secondly to enforce it. Within the next week or two the maximum fine would be increased from £200 to £1,000, thanks in part to the efforts of the NFU. It could not now be said that the bye-law was not worth enforcing.

MR. M. PAYNE (National Farmers Union) remarked that the Union was grateful to the NSCA for the invitation to attend the session and speak in the discussion. A paper entitled "Air pollution created by agriculture, the need for control", certainly attracted NFU's interest. His colleague had already spoken about straw burning; he wished to comment on the question of odour pollution in particular. The title of the paper related to agriculture and he wished to draw attention to the fact that the disposal of human sludge by water authorities was not agriculture. 74% of sewage sludge was disposed of to agricultural land and farmers were prepared to allow their land to be used for that purpose because it has some small benefit to them but by and large the general reason for the practice was that it was by far and away the cheapest method of disposal of sewage sludge. If the question of additional control of agriculture was brought about by reason of Water Authorities' preferred method of disposal, then he thought that farmers would very quickly close their doors to that method of disposal, and as a result local ratepayers bills from the Water Authorities for sewage disposal would increase substantially. He felt therefore that that part of the paper could be dispensed with in that context.

The question of nuisance resulting from livestock units was a difficult one. As the Royal Commission had recognised, livestock could not be kept without some smell; that was simply a natural part of keeping livestock even by traditional methods. The NFU accepted that some of the new methods could cause very nasty smells and considerable steps were taken to encourage farmers to observe the code of best practicable means already referred to in a different context, which was embodied in the legislation. In the Union's view, the legislation at present available did provide an adequate means for controlling nuisance which arose from agricultural livestock units although it was acknowledged that there were, in special areas particularly Humberside, unusual concentrations; Humberside was the second densest area for pigs in Europe and special measures might be necessary in this area. The NFU view of the section relating to further necessary controls was that they had not been demonstrated as necessary by the paper. The existing methods of control were by and large quite satisfactory and in fact the paper drew attention to Section 220 of the Local Government Act which provided further controls for local authorities should they need them. Mr Payne thought that the case for any new legislation still remained to be made and if the NSCA wished to adopt the case it would need rather more evidence than was currently available.

MR. D. RANDON (National Coal Board) wished first to make a few points on the paper given by Mr. Parkinson and Mr. Sidebottom. He had lived in two areas where soil erosion and dust blow were liable to occur - North Nottinghamshire and the Vale of York - and it seemed to him that recent farming practices had exacerbated the problem; in particular the removal of hedgerows.

A point, not mentioned in the paper but relating to nuisance, on which Mr. Randon also invited comment was the muddying of roads by farm tractors and heavy haulage vehicles carrying sugar beef etc. The National Coal Board had to take very stringent precautions to prevent the carrying onto the highways of mud from its operational and constructional sites, and it seemed rather strange that NCB vehicles left the site in a reasonably clean condition to go onto roads heavily littered with mud and materials brought out of fields.

With regard to stubble burning, Mr. Randon knew of two cases where safety and economic aspects had been involved. Within the last two months he had witnessed a road traffic accident caused by the density of smoke and also knew of a case where a cottage was burned to the ground resulting directly from stubble burning. The partially burned material had been carried into the atmosphere in calm conditions because of the thermal effect; the material had been deposited in a cottage's thatched roof, and the result had been rather inevitable.

Turning to the second paper, Mr. Randon wondered whether Dr. Ellis would like to comment on the importance of good blasting practice in connection with the slide he had shown of dust created by quarry blasting. Was there any possibility of improved control of dust through the type of stemming (i.e. the inert material placed in the hole) above the explosive or by any other technique?

CLLR. J.M. BRAMLEY (Selby District Council) said that, as a farmer and a member of a water authority, he felt under considerable attack from all sides - including representatives of the NCB and CEGB. Mr. Parkinson, Chief Environmental Health Officer of Selby, had presumably realised the risk of offending his Chairman (Cllr. Bramley himself) in his presentation! Nevertheless, the clear message that Cllr. Bramley had received, during the session and during the conference as a whole, was that people got what they paid for. If they were prepared to pay enough, they could get whatever they wanted. Farmers, however, had always been required to keep down the cost of food. They had done so, but at a cost - to the environment, in the case of straw and stubble burning. He was certain that any farmer would be only too pleased to sell, or even give away, surplus straw if it could be cleared off the land in a reasonable way. That, however, was not possible.

The UK imported wood from all over the world to make paper, and yet Cllr. Bramley understood that straw could equally well be used for that purpose. He had been told, however, that it was easier to import the wood than to use the country's surplus straw. Quoting the saying: "Where there's a will, there's a way", Cllr. Bramley expressed his regret that the will was not yet as strong as it should be.

MR. D. BIRD (NSCA Yorkshire & Humberside Division) had a question for Dr. Ellis, connected with the point made in his paper about the Buxton Liaison Committee. From the discussions which he had had with one or two people at Conference, it seemed quite an excellent Committee: it had been set up in exactly the right way, with exactly the right co-operation, and had discussed a number of environmental issues, apart from dust suppression. There were a number of Liaison Committees throughout the country but those that had been set up by the Inspectorate in Mr. Bird's own area had tended only to discuss one aspect of the problem; when local residents had wanted to move on to other encironmental problems there had been a little reluctance initially to broaden the terms of reference of the Committee to discuss environmental factors other than the ones strictly of concern to the Alkali Inspectorate. He felt it important, therefore, to set up Committees at an early stage in a joint manner.

Mr. Bird also noted that the District Alkali Inspectors were preparing reports that year; certainly their local report had crossed desks and was being discussed. He would be interested to know whether or not reports from other districts would be available to local authorities outside those districts and just exactly what form the Chief Inspector's Report would take. Would it comprise other district reports? For if District Alkali Inspectors were able to go into more detail in their own annual reports, it would provide helpful information about liaison committees such as the Buxton one.

MR. D. ECKERSLEY (Oldham Metropolitan Borough Council) said that as far as he was aware, there had been no reference made at all in the presentations on agricultural pollution, to pollution caused by swill boiling for pig food. In his authority he had an area of about a quarter mile square in which there were six pig farms which dealt with in the order of 10,000 pigs. Four of those pig farms had licences from the Ministry of Agriculture, Fisheries and Food to process slaughter-house waste. As could be imagined that often caused serious odour problems. He wondered whether his two colleagues from Yorkshire had any comments on that particular problem which might be of assistance to him in solving the problem.

MR. W. F. SNOW (Chairman) said that before calling on the speakers to reply, he would use the Chairman's privilege to ask two questions himself. The first one, to Mr. Parkinson and Mr. Sidebottom, concerned problems that they might have experienced of either noise and/or air pollution from crop spraying involving aircraft in their districts. The other question was on the dust suppression from vehicle movement referred to in

Dr. Ellis's paper. He wondered whether the industry had considered using water sprays attached to the vehicles which were actually permanently on the site, to help try and keep the dust down in their movements to the quarry face and back to the crushing plant. That might be more effective than the use of a bowser.

MR. J.B. SIDEBOTTOM (Author) welcomed the support from the floor for controls on straw and stubble burning. The matter had to be taken further; scientific evidence was needed to support the NSCA's case for whatever legislative reform be sought, as Mr. Blewitt and Mr. Clarke had pointed out. He emphasised that at that time there was, as the slide presentation had shown, no suitable alternative to burning; he and Mr. Parkinson had talked to some members of the NFU who had agreed on that point.

The authors had shown in their presentation the two slides from the manufacturers who had had an idea of converting straw to fuel on farm. The total blankness of the slides showed the degree of support for promoting the idea that the authors had received. There had been no positive reaction from the agriculture engineering industry. There also seemed to be no reaction to new ideas of straw utilisation from farmers, because it was so easy to set light to the straw and stubble, as there was no economic alternative available at the moment. There was considerable research going on into digging it in, chopping it up, converting it to fuel,but in real terms nothing was being developed. If an economic alternative was found which gave some incentive to farmers, he felt that straw and stubble burning would stop overnight.

Some farmers argued that stubble burning was a necessary practice from an agricultural point of view, to clear and cleanse the fields for the next year's crop. It reduced the enzymes, breaking them down which was supposed to give the crop a better chance the following year. However, Mr. Sidebottom and Mr. Parkinson were not 100% sure of the truth of that argument. They were not truly converted to the idea, because the current method of burning did not produce a true full burn across the field.

Nevertheless, scientific evidence was required in order to step further forward in resolving the problem effectively.

Referring to Mr. Collier's and Mr. Pane's remarks, Mr. Sidebottom said that both he and Mr. Parkinson realised that if all the notifications were made during the crop burning season, every Environmental Health Officer and every fire brigade could be overwhelmed with telephone calls. However, there was the attitude of the public to be considered. He, and Mr. Parkinson, had checked throughout their areas, which contained hundreds of grain growing acres, asking the people what they felt about straw and stubble burning. They had replied: "We know it's going on and we sort of accept it". They seemed to have had only one eye on the matter. The slides had illustrated the degree of interest and the attitude of the general population, who felt that nothing could be done. Therefore, they appeared simply to ignore it and accept that they were prisoners in the situation.

Whilst agreeing that there was insufficient manpower in local authorities, both he and Mr. Parkinson also felt that the new code of the NFU was only a palliative in the main cause of pollution prevention. A proper, economic, workable alternative to straw burning had to be found. So far, economists and scientists had failed to come up with an answer. In the meantime, they both completely agreed that local authorities had to enforce the byelaws and impose them vigorously.

Mr. Sidebottom fully agreed with Mr. Randon's question regarding spillage and mud on the roads. That was a factor that caused considerable concern to a large number of people. It was a very important point and both authors were glad that it had been brought to the attention of the Conference. Concerning accidents on the road as a direct result of straw and stubble burning, he said that enforcement lay with the Health and Safety Executive; there had been one or two fatalities linked with straw burning where the smoke had obscured the road and it was a very serious point. The authors felt that any new legal code should be enforced by the EHO's of the local authority so that there would be local contact direct to the complainant. EHO's were local and outnumbered HSE Inspectors. Turning to Mr. Eckersley's question on swill boiling, Mr. Sidebottom said that in his experience in his area it had been impossible to stop the smell from swill boiling. Deodourisers and such things had been tried, but to no effect whatsoever. Success came with conversion to dry feeding; the smell ceased from that point.

Finally, on the point about slaughterhouse waste to land, Mr. Sidebottom said that that problem had occurred in his area on three occasions in one year, on three consecutive days. One of the employees of a slaughterhouse had sprayed blood and other materials all over three different farmers' fields. He had spoken to the slaughterhouse owner about the matter, telling him that if it happened again, other pressure would be brought to bear. It was a fairly foul offensive occurrence and which had ceased; if it had continued, Mr. Sidebottom said that he would have had to take other steps. He did not know quite what he would have done in that particular case because it had been the slaughterhouse's driver trying perhaps to do a good turn for his boss - in actual fact he had done him a bad turn.

MR. N.H. PARKINSON, replying to Mr. Barry's point about measuring an odour, said that he and Mr. Sidebottom had not been aware of any instrument or machine for that purpose and would welcome more information from Mr. Barry.

Social survey techniques obviously formed a large part of any investigation carried out into any nuisance, whether it was of noise, odour or whatever; if such surveys were not carried out the telephone would be ringing constantly. Depending on the severity of the nuisance the general public provided the social survey data themselves via the press or other outlets of opinion. When dealing with statutory nuisances, it was necessary to depend very heavily on the experience gained over the years. Mr. Collier had made the point that human sludge to land was not agricultural pollution. He could not accept that particular point. It was difficult to tell the general public when they telephoned about a nuisance on the farmer's field that it was not the farmer's responsibility, but that of the Water Authority. He considered that the farmer had a responsibility. The farmer often entered into a contract with the water authority concerned, to plow in the sludge within a short space of time following its deposition, and frequently the farmer failed to honour that commitment. He did not seek to excuse the water authorities: he thought that they were the worst offenders in the odour nuisance situation because they sprayed sludge onto land. It disappointed him that after spending literally hours converting the minds of the pig farmers in the Selby area to using modern techniques of spreading their pig slurry, the water authority came along and placed literally hundreds of thousand of gallons of human sludge onto land by means of rain gunning. That put the clock back several years.

Answering Cllr. Bramley's point, Mr. Parkinson said that he was pleased to be able to say that his salary was fixed upon population. However, he was sensitive to the fact that Cllr. Bramley was a farmer and appreciated many of the points made, while he equally appreciated his point of view. Cllr. Bramley had said that in the end people got what they paid for, and Mr. Parkinson agreed that the question of economics was all-important. The message which he and Mr. Sidebottom had been trying to get across was that farming had changed. Intensive rearing was really big industry. What they were saying to the farmers was that the time had now come for them to look again at the practices, to try and live with their neighbours, with the general public, and keep nuisance to a minimum. He was fairly sure that with persuasion the aims set out in the paper for a change in practice and a change in legislation would be achievable. The farming community was fairly co-operative, by and large, and he hoped that matters could be dealt with informally as much as possible.

If the time came when there had to be legislation (and he thought that the time had come with regard to the rain gun, whether it was used by the water authorities or the farmers) then it should be introduced.

Mr. Snow had raised the question of crop spraying. Mr. Parkinson said that complaints were, surprisingly, relatively small in number. The Aviation Authorities who enforced the legislation for crop spraying along with the Health and Safety Executive Agricultural Inspectorate had improved considerably their system of dealing with complaints. Since the contractors had started to use helicopters rather than the old type plane, the situation had improved enormously. The profile of the spray had got much lower to the ground and very, very few complaints were received. That applied not only in Selby, but right across the country.

DR. A.F. ELLIS, replying to points raised during the discussion, dealt first with Mr. Snow's suggestion for water sprays on vehicles. He said that it would be a good idea but the difficulty arose from the majority of vehicles being contractors' lorries coming on site for a load of stone, for example. Clearly those vehicles could not be fitted with spraying equipment, which might be arranged for those permanently on site. The same problem existed with the positioning of exhaust pipes, as shown in his paper. Quarry vehicles could be designed to direct their exhaust pipes away from the ground, but that was much more difficult to arrange with contractors' vehicles.

Mr. Bird had mentioned the need when setting up Liaison Committees for wide consultation involving the Inspectorate and the local authority. Dr. Ellis said that naturally he fully agreed with that. He belonged to three or four such Committees which all ran in much the same way, all allowing the public who were present to have a full say on all matters which they wished to include. As a rule it was found that if they had their say in the way he had discussed, they left the meeting much more contented than if many of the topics were vetoed. Mr. Bird had also mentioned that the fact that District Alkali Inspectors had produced open reports for the first time in 1982. That was an innovation and was done by way of a trial for the moment. All reports were available to be read by anyone who was interested.

The Chief Alkali Inspector's report, which had been published the previous week, took account of that new style of District reporting. He had concentrated on certain topics of interest that year, for example sulphur dioxide, and instead of referring to all scheduled processes coming under his responsibility, had concentrated on certain of these where there had been developments of interest to report.

There had been a question on blasting practice and on achieving reduced dust levels in the future. Dr. Ellis had to admit that he was very short of information on that aspect; it might well be that there were other people in the room who knew more than he did himself. The Mines and Quarries Inspectorate took a primary interest in that side and he could not add anything to that at the moment.

Mr. Clarke had asked a question on whether the effects of diesel fuelled mobile plant added to the problems of quarrying. Within his own experience, the extent of the use of such plant was very limited in the context of the overall quarrying scene and so it was unlikely that there was any significant increased air pollution in such cases. Dr. Ellis said that that would be his conclusion although he would not be able to provide figures to support it!

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TRANSITION TO COAL IN INDUSTRY

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Shell Boiler Division

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INTRODUCTION

Before considering the relatively major step of changing from one source of energy to another, the Industrialist must first satisfy himself that the change is warranted over the full life of the plant under consideration. Most energy conversion plants will have a life of 15 to 20 years, depending on the operational conditions to which it is subjected, and energy availability is dependant upon the international scene rather than local considerations.

Present extractable world resources expressed in tonnes of coal equivalent (FIGURE 1) indicate that the world has 250 + years of coal, 35 + years of oil and 40 + years of gas. The United Kingdom has known coal resources of 45×10^9 tonnes which is one-fourteenth of the world reserves. A large percentage of the world oil reserves are either in politically unstable areas or behind the Iron Curtain, both presenting concern for the continuity of supply. The Middle East accounts for 53.5% of the world's proven oil reserves and over 27% of total oil production and economists predict that the recent fall in oil prices will be overtaken by an increase in demand: this increase in demand being stimulated by an improvement in the world economies and a relaxation of conservation measures.

Although the United Kingdom is ideally placed with the advent of North Sea oil, it is doubtful that large quantities of this oil will be available for burning in industrial boilers or furnaces. It is, therefore, clear logic that Industry must seriously consider installing plant which is capable of burning the country's most available indigenous fuel.

(1) INCENTIVES

In 1981, under Section 8 of the Industry Act 1972, the Government via the Department of Energy and implemented by the Department of Industry, made available £50M to be expended as a grant to assist Industry to replace or convert oil fired boilers to coal firing. At that time it was confined to boilers, had a limit of 25% of the eligible costs and was only available for schemes with costs in excess of £25,000. Present legislation allows consideration to be given to replace or convert from either gas or oil, and is applicable to furnaces, hot gas generators and selected plant other than boilers. The limit is still 25% of the eligible costs, but schemes over £15,000 will be considered. Grants in excess of £5 M will require Parliamentary approval.

Applications under the scheme must be submitted by 31 March 1983, and projects completed by 31 March 1985, except in the case of large projects requiring a longer period of construction. A major consideration in the application is the "additionality" clause, whereby Industry has to confirm that they would not proceed without a grant or alternatively would require a grant to accelerate their intentions. Projects over £2 M total costs are referred for special consideration and the percentage grant has varied in these cases between 15% to 25%. It should not be expected that the 25% limit is in anyway automatically approved. Funds are still available as only approximately 50% of the £50 M available has been offered.

Other grants are available under the Demonstration Scheme of the European Community for Energy Saving Projects Regulation (EEC) Number 1303/78. The basic requirement for consideration is that the proposal is for a full scale plant, not an "initial study" or "prototype" (this work must already have been completed), that it is capable of being repeated throughout the EEC, that it saves a significant amount of energy and that it is clearly economically viable with a short financial pay back period. If there are no commercial or technical risks, then it is doubtful that an application would be considered. Grants once agreed could cover 25% to 49% of the total cost but in the event of the project being a success then from that time the grant becomes a loan, with repayment on average over eight years. Normal replacement or conversion of conventional plant from oil/gas to coal without novel innovation would in all probability fail to qualify.

The major incentive to change from either oil or gas to coal must be the cost of the fuel. FIGURE 2 shows these cost comparisons per therm at the time of going to press. The 35% advantage of coal to any energy related business means that in most cases capital expenditure tailored to meet their needs can be paid back in two to three years. This is a very attractive proposition to any industry about to consider new boiler plant and statistics show that advantage is being steadily taken of this opportunity. On small and medium sized boilers, orders for coal fired units have moved from 4.1% of the market in 1978 to 16.4% in 1981, with indications of further increased penetration in 1982. In the case of the Babcock Power Limited, Shell Boiler Division, which incidentally covers all types of boilers - fire tube or water tube units up to 100,000 lbs per hour (29 M W), the orders taken in 1982 show 54% for coal firing by numbers of boilers, and 65% by evaporation. This confirms the opinion that it is highly probable that small installations will remain on oil/gas and larger installations will move to coal firing.

(2) SELECTION OF BOILER PLANT

The availability of coal to suit many forms of firing should not present any problem in the United Kingdom. Equally, in the United Kingdom, special consideration need not be given to suit high sulphur (average 1.5%) or high chlorine coals and it is interesting to note that on average a boiler plant fired with average United Kingdom coal produces 28% less SO_2 per unit of heat release, than does average quality industrial oil. Chlorine when present is more of a problem for the boiler owing to its sticky properties when condensing on a cooled surface, than its effect on the environment.

The selection of plant, therefore, resolves itself down to the usage to which the plant is required to conform. Four properties are paramount:

(a) The range of load
(b) The response to load changes
(c) Operational steam pressure
(d) Local environmental requirements

(a) Shell Boilers

All fired shell boilers are restricted in output to approximately 32,000 lbs per hour (9.4 M W) on good coal up to pressures of 250 p s i (17.24 Bar) with no superheat. Such a unit would require twin stokers and too many multiples of such units would be accompanied by a heavy maintenance cost in both staff and material. Most industrial installations have a variable winter to summer load and often this decides the sizes of multiple units - wherever possible the larger the boiler selected, the less capital cost per pound of steam, the less maintenance and the less operation staff. There is, however, no hard rule and each project has to be considered on its own merit. A typical shell boiler is shown in FIGURE 3.

Mass burning grates in a shell boiler have a reasonable response to load changes but need time to re-stabilise optimum burning conditions. A shell boiler needed to meet rapid load changes would have to incorporate thermal storage which uses the shell steam/water space as an accumulator. Operational pressures in a coal fired shell boiler rarely exceed 300 p s i (20.69 Bar) and at 350 p s i (24.14 Bar) the size of the boiler is considerably reduced with corresponding reduction in evaporation.

All shell boilers firing coal require down time to clean between statutory inspections (14 months). Depending upon the coal this can in the worst case be as often as every three weeks, and in the best case every twelve weeks. Practical experience averages out at about eight weeks between cleans.

Experiments are now taking place firing shell boilers on pulverised fuel, but here the auxiliary plant, both on the coal preparation/storage side and the gas clean up systems, add significantly to the costs. Fluidised beds in shell boilers present problems with high gas velocities, inadequate free board and hence carry over with associated erosion problems.

(b) Composite (COMPO) Boilers

Historically, a coal fired Boiler House was served by either shell boilers or water tube boilers. Water tube boilers have no real limitations other than price and can be designed to meet evaporation of 2,322,250 lbs per hour (660 M W) and pressures up to 2,360 p s i (162.76 Bar) at steam temperatures of 1,055°F (568° C). The latter, used for generation at Utility Power Stations, are outside the scope of this paper. However, to overcome this historical price differential at lower evaporations, Babcock have designed and are installing a relatively new design concept incorporating the best of water tube and fire tube technology, assembled out of proved modules. Hence the word "composite (COMPO)" boiler (FIGURE 4).

Coal can be burnt in this furnace by using mass burning grates, spreader stokers or a fluidised bed, and lends itself to be designed to burn a percentage of selected waste products mixed with the coal.

The mass burning grate is similar in construction to that used in a shell boiler with combustion taking place progressively from front to rear of the boiler.

Coal is fed on to the grate in an even layer, ignition being maintained by a refractory arch. Burning takes place from the top to the bottom of the coal and a relatively high temperature is maintained over most of the grate length. Entrainment of particles in the flue gas is kept at a minimum, but if chlorine is present, metallic chlorides can produce sticky layers which foul the boiler tube surfaces causing cleaning problems.

Spreader stokers offer a means of very quick response to load changes, burn up to 30% of the coal in suspension in the furnace, produce a friable fly ash which is easy to remove, subjects the chain to high temperatures over only a section of its length but, unfortunately, entrained particles increase and have to be removed by more expensive gas clean up systems than required by a mass burning grate. In spreader firing carbon carry over is maintained at similar levels as on chain grates by grit refiring, and the coal on the grate burns from the bottom to the top of the bed giving a better and more even combustion performance.

Fluidised bed firing burns a wider range of coals than either spreaders or mass burning grates but produces fine particle entrainment in flue gases. This type of firing on COMPO boilers has financial attractions by maintaining efficiency over the life of the plant, almost eliminating cleaning between statutory overhauls (twenty-six months). There are no moving parts hence lower maintenance but the capital cost of gas clean up systems is higher.

COMPO boilers are suitable for evaporations up to 100,000 lbs per (29 M W) and pressures of 500 p s i (34.5 Bar) with or without thermal storage. There are no problems in installing superheaters.

(c) Water Tube Boilers

These are normally (within the Industrial market) considered for pressures up to 900 p s i (62 Bar) 950^o F (510^o C) and, dependant upon design, there is no real limit to evaporation. The market has a requirement for a low cost water tube for low to high pressures in order to meet industrial process and generation needs, and a number of firms can offer such a design (FIGURE 5). Here again, it can be supplied with any of the three types of combustion equipment previously described with the same benefits and disadvantages.

(3) GAS CLEAN UP PLANT

In the previous sections of this paper the selection of boiler plant produced varying emissions from the final boiler pass necessitating a different approach in each case when considering complying with the Clean Air Act or the requirements of the Alkali Inspectors for registered processes.

The type of plant available can be broadly divided into five categories.

(a) Settling Chambers
(b) Mechanical Collectors or Grit Arrestors
(c) Bag Filters
(d) Washers or Scrubbers
(e) Electrostatic Precipitators

This list is in ascending order of capital cost which in most cases has a major effect on the viability of the project. The go/no go line probably falls between items (c) and (d) with item (e) out of reach to most small/medium installations burning coal, other than pulverised fuel. The intention is to remain, where possible, with a combination of (a) and (b).

The selection of plant must comply with legislation at the same time keeping costs to a minimum. The variation of these costs can be judged by the following guide lines:

Simple Collectors for small packaged boilers	15p per cfm
Multi-Cell Collector for mass burning grates	50p per cfm
High efficiency collectors for spreader stokers and fluidised bed boilers	90p per cfm
Fabric bag filters - depending on temperature	£3.00 to £5.00 per cfm
Electrostatic precipitators - depending on size (Sulphur content 1%)	£5.00 + per cfm

It should, however, be noted that capital costs of collecting equipment cannot be taken in isolation and must be costed as a package involving such ancillary equipment as ducting, supporting steelwork, fans and dust disposal plant. It is preferable that a single contractor supplies both the fans and the collecting equipment to avoid demarcation of responsibility for performance. Maintenance costs on this equipment are generally small and are confined to cleaning during boiler plants annual/bi-annual overhaul.

To reduce capital costs on spreader stokers and fluidised bed fired boilers experiments are actively being conducted on multi-cell collectors with a suction created under the cells to prevent re-circulation of fine particles. The resultant gas (approximately 12½% by volume) plus fine particles is passed through a high efficiency collector or bag filter tailor designed for the purposes.

A comparison of the various types of collectors and associated efficiencies, power consumption etc., is shown in FIGURE 6. Both power consumption and pressure drops must form an integral part of any overall scheme evaluation.

(4) COAL HANDLING

The concept of large areas of coal stacks, open to the elements - running wet in winter and blowing dust everywhere in summer, need no longer exist.

In the changeover from oil/gas to coal, in many cases the location of the Boiler House does not provide accessible areas in which to store coal. Silos (FIGURE 7) are now available which are formed out of steel, polyester or concrete with capacities up to approximately 1,100 tons (1,117 tonnes). This size would have a diameter of 30 feet (9.1 Metres) and a height of 90 feet (27.4 Metres). Normally silos of 300 ton (305 tonnes) capacity are the optimum for most industrial installations, being 60 feet (18.3 Metres) high and 20 feet (16 Metres) in diameter. Conveyance of the coal from these hoppers to the boiler can be totally enclosed in pipelines using high pressure air as the conveying medium. This is particularly suitable to "washed smalls" coal which is dense in structure and can be conveyed under pressure in the form of a slug. There are limitations to distance and height through which the coal can be conveyed by the initiating pressure, but here booster points can be employed to overcome the problem. The attraction is that as the coal is totally contained the coal handling area is clean.

The converse is only price in the case of both silos and pneumatic conveyance, but this must be off-set by higher maintenance costs on belt or drag link conveyors.

Screw conveyors are only suitable for "washed single" coals conveyed over relatively small distances.

(5) ASH-HANDLING

Coarse ash can be removed by water sluicing, drag link conveyance, or by crushing and transporting by pneumatic means. Fine ash lends itself admirably to pneumatic conveyance provided the total system is sealed throughout. The days of opening hoppers into un-sealed barrows should now have gone. Once again, selection is all-dependant on the cost which the industrialist is prepared to consider and meet.

So far reference has only been made to reducing the entrained solids in the products of combustion. Although of a minor nature on United Kingdom coals, SO_2, SO_3 in gaseous form is also emitted. In conventional stoker firing, 10% to 15% of the sulphur in the coal is retained in the ash, this percentage increasing to 30% in the case of fluidised bed combustion. Pulverised fuel firing, on the other hand, increases the emission of SO_2. United Kingdom legislation seeks to control SO_2 emission by limiting ground level concentrations to an acceptable value by dispersion from a "tall chimney", and dilution into the atmosphere. NO_x and other pollutant trace elements are dealt with in a similar manner. Increase in legislation to limit these emissions further can only result in some form of gas washing which in itself produces a polluted effluent and the problem of how and where to dispose of same. Fluidised bed technology coupled with deep beds and the addition of limestone may be the answer - again disposal of the waste material is the problem. There is little evidence that the very small quantity of chlorine emitted from the chimney as chlorides proves a problem to the environment.

(6) TRAINING OF OPERATORS

Firstly, it must be accepted that a totally un-manned Boiler House is out of the question for a coal fired installation. It is probably true to say that more personal attention is required for coal than for oil/gas, if only for the reason that the condition of the fuel varies and, therefore, plant needs adjustment. Training of staff to meet these needs is best served by their appointment at an early stage of completion of new plant and for them to work alongside the Contractor's staff throughout commissioning. There is, unfortunately, a reluctance for existing staff to welcome the advent of coal firing, which is probably understandable when considering the type of plant operating 15 to 20 years ago. Experience over the last five years has shown that this reluctance is steadily eroded once the new plant has been running for a short period and the benefit of modern equipment realised.

CONCLUSIONS

The proper selection of suitable plant for any change of fuel necessitates the careful consideration of many and often conflicting properties of each module making up the overall installation. Almost anything can be achieved if the money is available - in practice it evolves down to realistic compromises.

Small industrial establishments will in all probability remain dependent upon gas/oil for their energy. Medium and larger industries will progressively change to coal by the purchase of new plant, providing the price per therm differential remains above 10p., and site space is available. Conversion to coal firing from gas/oil will mainly be confined to water tube boiler installations. Controlled fluidised bed combustion is becoming a reality and could eventually displace stoker firing. Development work must be undertaken to improve collectors and bag filters to meet the needs of new equipment and tighter environmental control conditions. Clean environmental conditions both inside the installation and outside the factory, must be mediated in the short term by availability of funds in an unhealthy climate.

Conversely, Industry should carefully consider initial capital expenditure by installing properly designed enclosed systems where possible to minimise environmental hazards whilst taking advantage of reduced energy costs.

Government as well as Industry must play a substantial role in encouraging and uniting the efforts of the National Coal Board, plant contractors and the user, especially in fuel handling and waste extraction.

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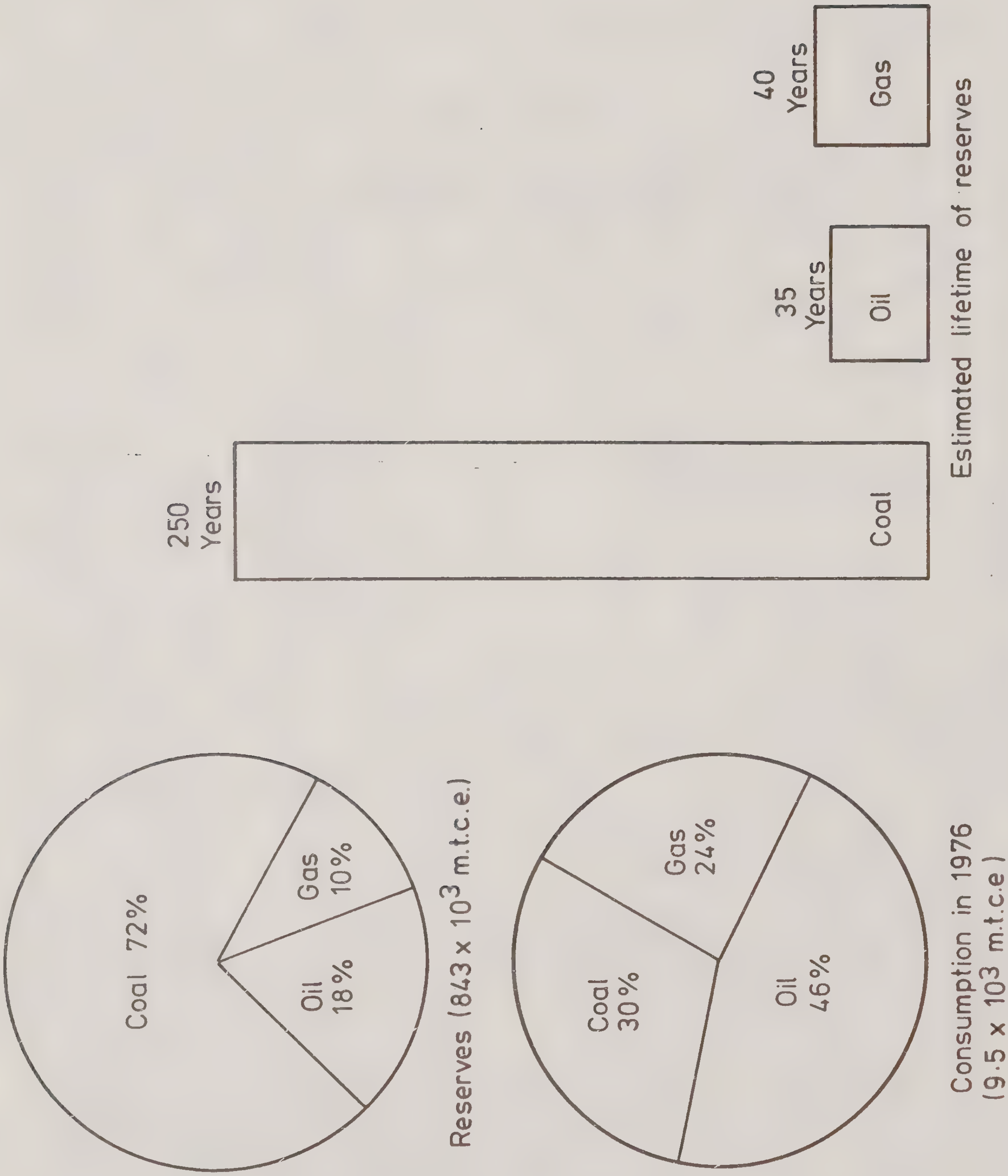
(6) "The Cost of Dust and Grit Collectors on Small Boiler Plants "
Mr H. Westwood - Howden Engineering Limited

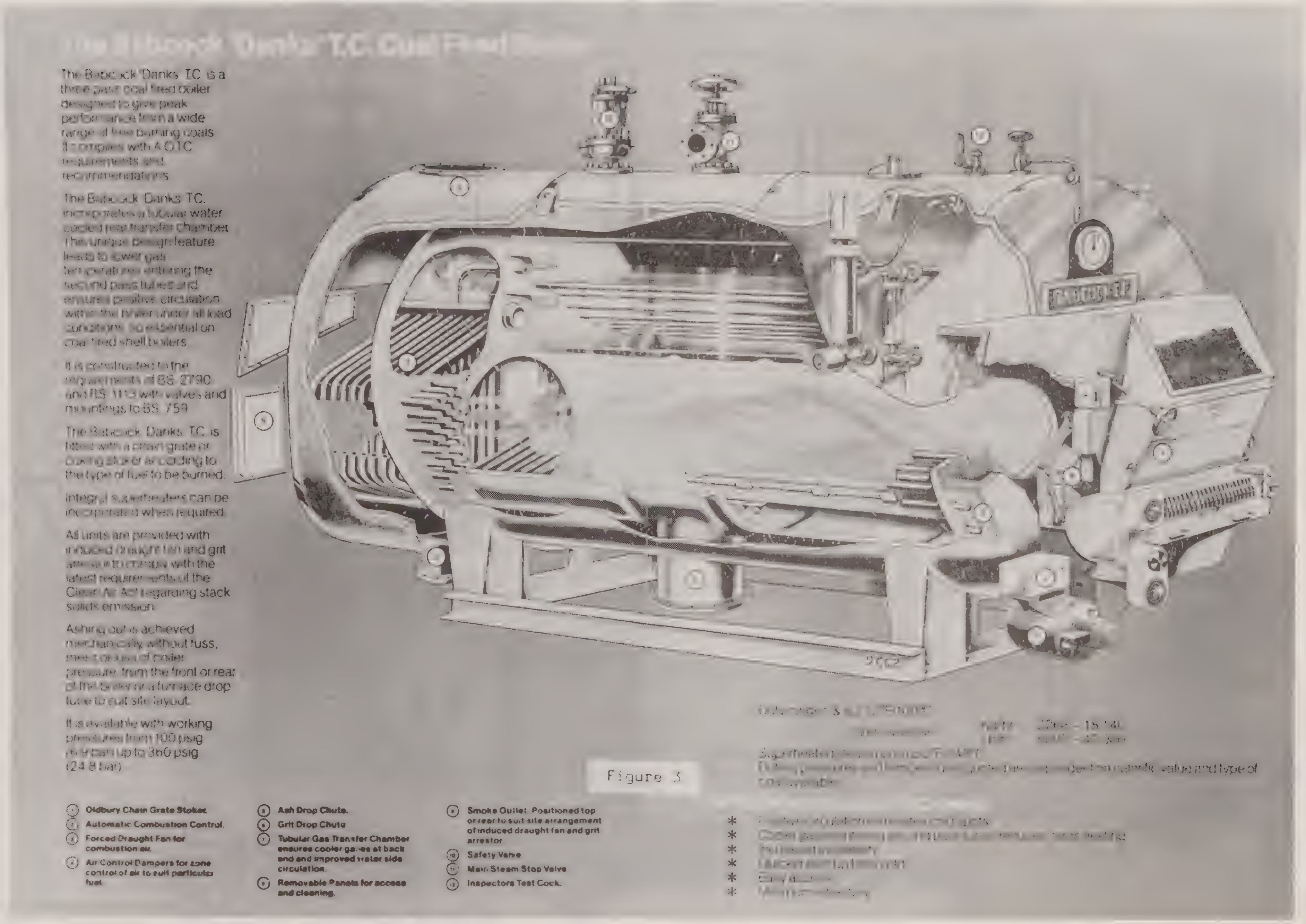
Figure 1



WORLD RESERVES AND CONSUMPTION OF FOSSIL FUELS

Figure 2

COST OF ENERGY PER THERM	
COAL	20 p (average)
HEAVY FUEL OIL	30 p to 32 p
NATURAL GAS	28 p to 30 p



The Babcock Danks T.C. Coal Fired Boiler

The Babcock Danks T.C. is a three pass coal fired boiler designed to give peak performance from a wide range of free burning coals. It complies with A.O.T.C. requirements and recommendations.

The Babcock Danks T.C. incorporates a tubular water cooled rear transfer chamber. This unique design feature leads to lower gas temperatures entering the second pass tubes and ensures positive circulation within the boiler under all load conditions, so essential on coal fired shell boilers.

It is constructed to the requirements of BS 2790 and BS 1113 with valves and mountings to BS 759.

The Babcock Danks T.C. is fitted with a chain grate or coking stoker according to the type of fuel to be burned.

Integral superheaters can be incorporated when required.

All units are provided with induced draught fan and grit arrestor to comply with the latest requirements of the Clean Air Act regarding stack solids emission.

Ashing out is achieved mechanically without fuss, irrespective of boiler pressure, from the front or rear of the boiler or a furnace drop tube to suit site layout.

It is available with working pressures from 100 psig (6.9 bar) up to 360 psig (24.8 bar).

1. Oldbury Chain Grate Stoker.
2. Automatic Combustion Control.
3. Forced Draught Fan for combustion air.
4. Air Control Dampers for zone control of air to suit particular fuel.
5. Ash Drop Chute.
6. Grit Drop Chute.
7. Tubular Gas Transfer Chamber ensures cooler gases at back end and improved water side circulation.
8. Removable Panels for access and cleaning.
9. Smoke Outlet. Positioned top or rear to suit site arrangement of induced draught fan and grit arrestor.
10. Safety Valve.
11. Main Steam Stop Valve.
12. Inspectors Test Cock.

[illegible]

[illegible]

Superheated [illegible]
[illegible] and type of [illegible]

- * [illegible]
- * [illegible]
- * [illegible]
- * [illegible]
- * [illegible]
- * [illegible]

Figure 3

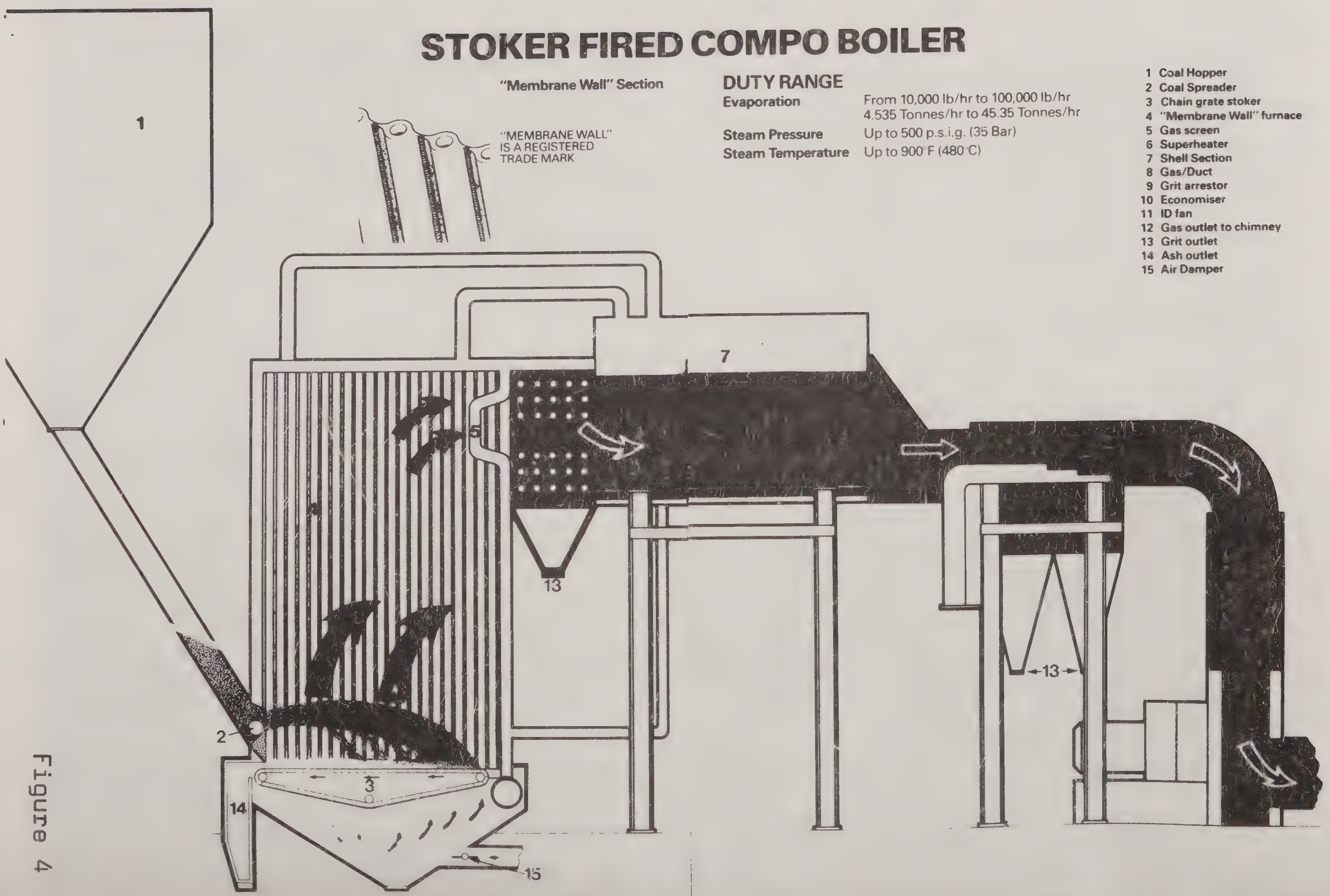
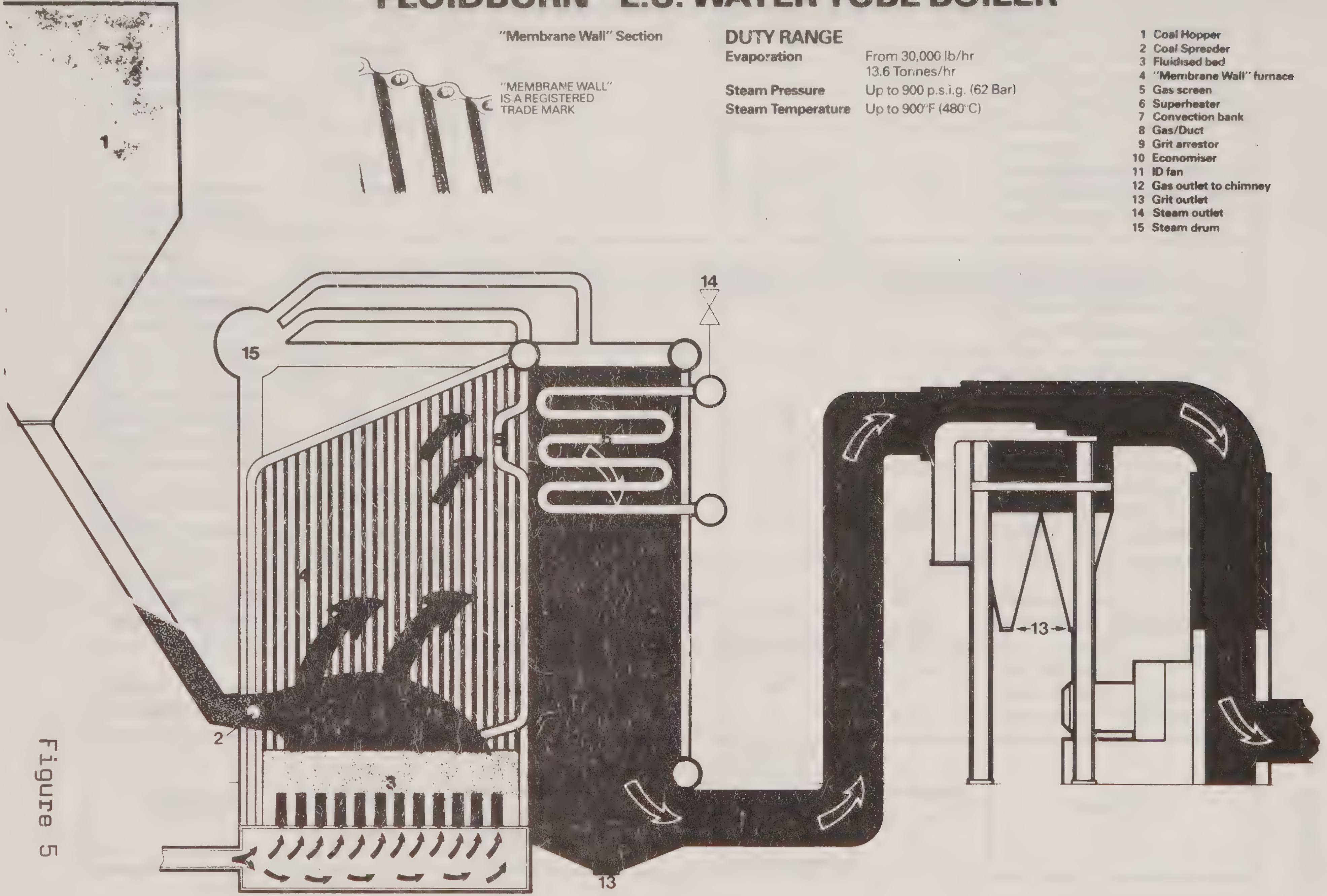

STOKER FIRED COMPO BOILER
"Membrane Wall" Section
"MEMBRANE WALL" IS A REGISTERED TRADE MARK
DUTY RANGE
Evaporation From 10,000 lb/hr to 100,000 lb/hr 4.535 Tonnes/hr to 45.35 Tonnes/hr
Steam Pressure Up to 500 p.s.i.g. (35 Bar)
Steam Temperature Up to 900°F (480°C)
1 Coal Hopper
2 Coal Spreader
3 Chain grate stoker
4 "Membrane Wall" furnace
5 Gas screen
6 Superheater
7 Shell Section
8 Gas/Duct
9 Grit arrestor
10 Economiser
11 ID fan
12 Gas outlet to chimney
13 Grit outlet
14 Ash outlet
15 Air Damper
1
7
13
13
2
3
14
15

Figure 4

"FLUIDBURN" L.S. WATER TUBE BOILER



DUTY RANGE

Evaporation	From 30,000 lb/hr 13.6 Tonnes/hr
Steam Pressure	Up to 900 p.s.i.g. (62 Bar)
Steam Temperature	Up to 900°F (480°C)

1	Coal Hopper
2	Coal Spreader
3	Fluidised bed
4	"Membrane Wall" furnace
5	Gas screen
6	Superheater
7	Convection bank
8	Gas/Duct
9	Grit arrestor
10	Economiser
11	ID fan
12	Gas outlet to chimney
13	Grit outlet
14	Steam outlet
15	Steam drum

Figure 5

Figure 6

COLLECTOR	Range of Gas Volume C F M	Average Temperature Of Normal Application ° F	Normal Pressure Drop "W G"	Approximate Power Required for Operation B H T per 1,000 C F M	Efficiency Percentages	REMARKS
Low Resistance Upflow Collector	1,000 to 30,000	700	0.2	NIL	60% to 80%	Suitable for installing in steel chimney. Operates on natural draught
Upflow Collector with Integral Secondary Collector	3,000 to 60,000	500	1.0	0.2	70% to 95%	Suitable for installing in steel chimney
Vortex Downflow Collector	3,000 to 70,000	550	1.5	0.3	80%	Usually placed before the Induced Draught Fan to give protection to the fan
Scroll Collector with separate secondary Collector	5,000 to 100,000	300	2.5	0.5	80%	Collecting efficiency is varied by selection of secondary Collector. No secondary fan required
"Straight Through" Cellular Collector with secondary Collector	20,000 upwards	300	1.5	0.31	95%	Small secondary fan required. Compact Collector requiring minimum of space
Reverse Flow Cellular Collector	5,000 upwards	300	2.5	0.5	95%	No secondary fan required. Collector can be arranged to have integral large capacity dust storage
High Efficiency Multi-Cyclone Collector	200 upwards	300	3.0	0.6	97.5%	This Collector is particularly suited to applications where dust is very fine and the highest efficiency required

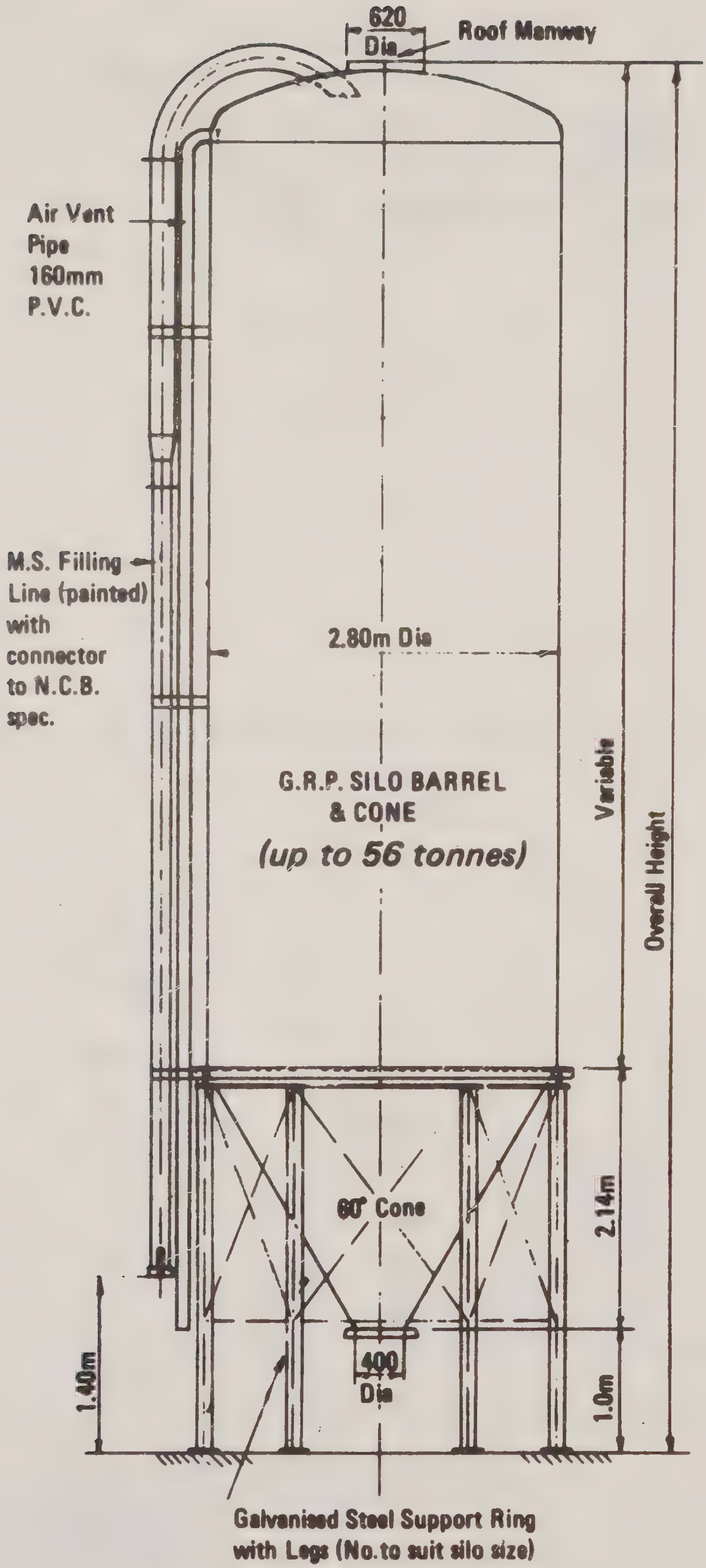

620
Dia
Roof Manway
Air Vent Pipe 160mm P.V.C.
M.S. Filling Line (painted) with connector to N.C.B. spec.
2.80m Dia
G.R.P. SILO BARREL & CONE
(up to 56 tonnes)
Variable
Overall Height
60° Cone
2.14m
1.40m
400
Dia
1.0m
Galvanised Steel Support Ring with Legs (No.to suit silo size)

Figure 7a

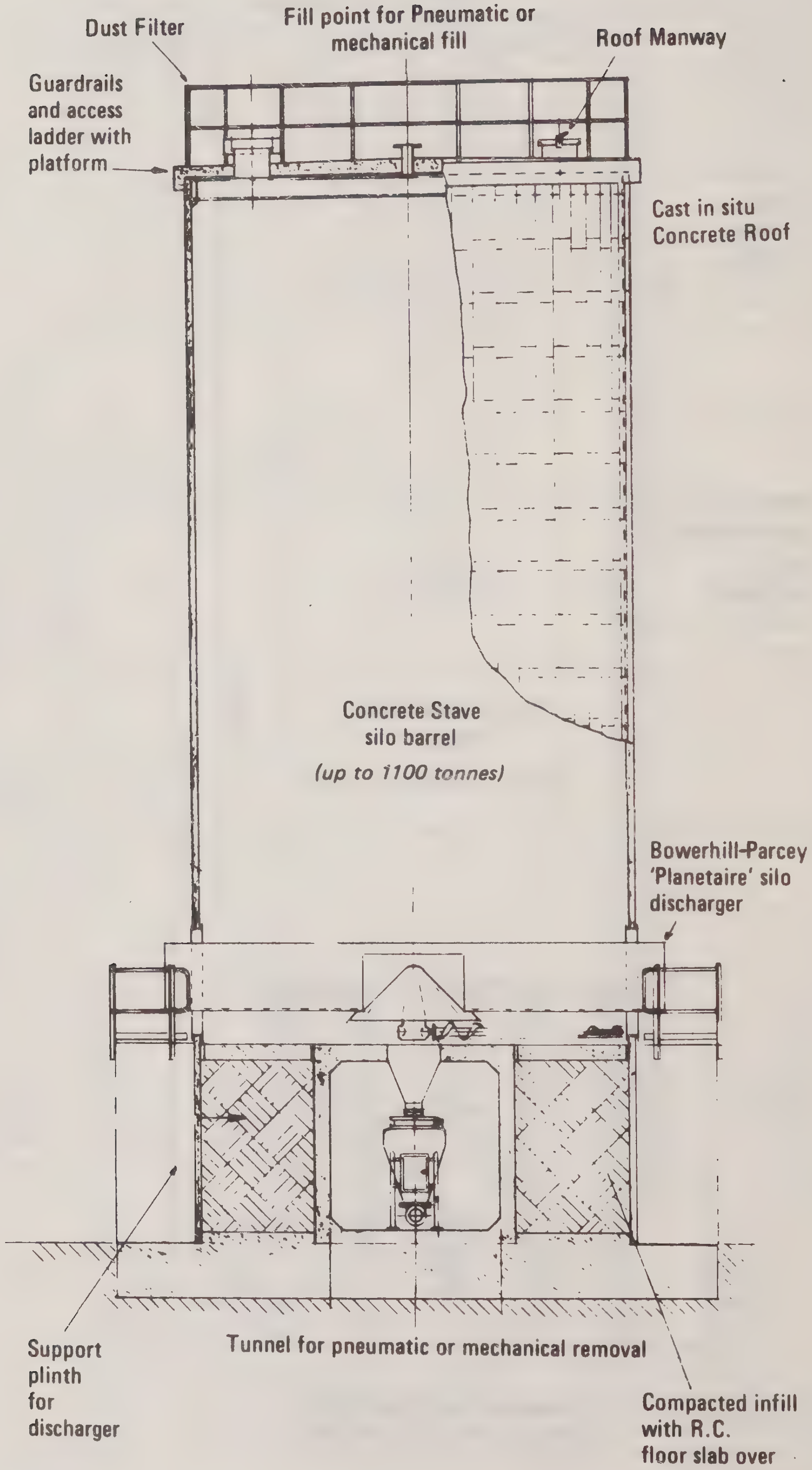

Dust Filter
Fill point for Pneumatic or mechanical fill
Roof Manway
Guardrails and access ladder with platform
Cast in situ Concrete Roof
Concrete Stave silo barrel
(up to 1100 tonnes)
Bowerhill-Parcey 'Planetaire' silo discharger
Support plinth for discharger
Tunnel for pneumatic or mechanical removal
Compacted infill with R.C. floor slab over

Figure 7b

nsca
49th ANNUAL CONFERENCE
19 OCTOBER 1982
LLANDUDNO

TECHNICAL DEVELOPMENTS IN INDUSTRIAL COAL UTILISATION

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SUMMARY

To make coal more attractive to industrial users, the NCB initiated work in 1972 on a variety of improvements to conventional industrial equipment and on new concepts, particularly fluidised bed combustion. Following NCB-sponsored demonstrations, many of the new developments are now commercially available from manufacturers.

Developments for conventional mechanical stokers have mainly been concerned with improving amenity. Most stokers are now available with automatic electrical ignition, load following and ash removal. Although fully established and reliable, stokers have two disadvantages: the operating parameters must be adjusted for the particular coal being fired for optimum performance and there is a gradual loss in boiler efficiency due to tube fouling by ash components, necessitating periodic shut-down for cleaning. The new technique of fluidised bed combustion (fbc) is immune to changes in coal type and, furthermore, the low temperature of combustion eliminates boiler fouling, so that optimum efficiency is maintained for extended operating periods. Fbc is particularly amenable to automatic control, giving a more rapid response than stokers. It also facilitates a reduction in emissions, although with the penalty of higher capital and operating costs. The successful operation of several prototype boilers has demonstrated the suitability of various designs, covering the industrial range of outputs and operating pressures, and orders are now being received by manufacturers for commercial versions.

To complement the improved firing systems, the NCB has encouraged the introduction of pneumatic coal conveying for handling coal on industrial sites. Two types are available, dense phase and dilute phase, used for smalls and singles grade coal, respectively. Both systems usually offer a lower capital cost than mechanical conveyors, with less maintenance and greater

reliability. The use of pneumatic conveying of coal, and also of ash, together with coal and ash storage in closed bunkers or silos, ensures that coal firing offers a degree of cleanliness previously associated only with oil or gas firing.

Introduction

During the last ten years increased international tension in major oil producing areas of the world, together with a realisation that world oil resources are limited has led to a rapid rise in oil prices. As a result, coal has become increasingly competitive. Reserves of coal are very substantial and are expected to last for hundreds of years rather than decades for oil and gas. Coal, therefore, is beginning to regain its former importance in supplying world energy needs.

Annual UK coal production is about 126 million tonnes. About 70% of this coal is used for power generation and this market is not expected to expand because future increases in electricity demand are expected to be met by nuclear power. The market which is expected to expand significantly in the remainder of this century is the provision of heat and energy for industry. Coal's present share of the industrial market is about 13% (10 million tpa) and this is expected to increase about three fold by the year 2000.

The National Coal Board recognised the increased potential for coal at a very early stage, and initiated research and development projects to improve all aspects of coal utilisation with priority directed to improving coal systems for industry. In 1972 a development programme concentrating on packaged boilers and their ancillaries, particularly coal and ash handling, was launched (1). As a result of this initiative, many equipment manufacturers are now collaborating with the NCB in this area and important advances have been made. Improvement of conventional stoker fired boilers has been achieved with increased automation, including automatic ignition and de-ashing. Pneumatic handling systems for coal and ash are now commercially available. The most important development for the future is expected to be fluidised bed combustion, with its ability to burn a wide variety of coals and promote high combustion intensity without boiler fouling, yielding more compact coal fired boilers.

It is also amenable to automatic control and facilitates suppression of sulphur dioxide, if required. It is expected that most of the increased industrial demand will be for coals that have been washed to remove stones, leaving only the ash which is part of the coal structure, typically 5% to 10%. High ash coals will only be used at or adjacent to mines, because of high transport costs. The NCB is committed to an investment programme in new preparation plants to meet the demand for washed coals. The coal will be marketed in two size grades, as at present. Singles coal, 25 mm to 13mm, will be supplied to smaller users, typically taking below 6,000 tonnes per year, because of the relatively low capital investment required for the storage and handling system. Smalls coal, usually 13 mm to zero, but sometimes with a top size of 18mm or 25mm, is supplied to larger users. Smalls are cheaper than singles, but more difficult to handle and require a higher capital investment which is only justified for a high coal usage. Developments in handling systems for both singles and smalls are discussed in Section 3.

2. Combustion of Coal

There is a very wide variety of coal firing equipment available(2) and it is necessary to select the most appropriate type for each application, taking into account the coal size-grade and its rank, i.e. volatile content and its tendency, when heated, to swell and stick together forming coke.

2.1 Conventional firing methods

For small heating boilers, up to 2 MW, which will use free-burning singles, the traditional firing method is an underfeed stoker. Conventional designs are well proven and reliable, but require manual lighting and ash removal (twice daily, at full output) and are somewhat inefficient. Following NCB development initiatives, manufacturers now offer more efficient units incorporating electrical ignition controlled by time clock and automatic de-ashing. In recent years, two reciprocating grate stokers have been introduced, providing fully automatic operation for outputs up to 2 MW. These are the Escom Stoker and the Proctor Mini-Coking Stoker. Several units of both designs are now in commercial operation.

For outputs in the range 2 MW to 5 MW the most cost-effective approach is to burn singles coal on a static grate with an above-bed spreading system (Figure 1). This concept was pioneered by GWB Parkinson Cowan (now Thorn EMI), and their Vekos boiler was the best-selling coal packaged boiler through the 1970's. Most boiler makers now offer similar units and Saacke market a front-fired system for conversion of existing boilers. This firing method is restricted to free burning singles and has the disadvantage that the ash must be manually removed from the boiler, three times daily at full output. The ash is pulled from the boiler into a clinker crusher, which delivers it to an automatic conveying system. Several companies are developing automatic de-ashing units and these are expected to be commercially available soon.

Coals which swell and stick together when heated are usually reserved for the production of metallurgical coke, but they can be fired successfully in a reciprocating-grate coking stoker, which provides agitation of the fuel bed.

For outputs above 5 MW it is usually economic to burn smalls rather than singles. In package boilers, smalls are fired using a chain grate stoker. These units are well developed and provide fully automatic load following and ash extraction. A recent development, initiated by the NCB, is the provision of electrical ignition, initiated by time clock. This eliminates the waste of coal in the traditional overnight 'banking'. Chain grates are also used for outputs below 5 MW when automatic de-ashing is required and they can burn singles if necessary.

For water tube boilers up to about 100 MW, smalls coal is fired using either a travelling grate, which is similar to a chain grate, or a spreader stoker above a moving grate, to provide de-ashing. Both types of stoker are well developed and fully automatic. Above 100 MW the size of grate becomes excessive and it is then economic to pulverise the coal and fire it in suspension, forming a flame. The pulverised fuel (pf) size is typically 90% below 70 microns and the mills are expensive, power consuming, and require considerable maintenance. However, pf firing is a refined and proven technology and is used in modern power stations, in the UK and worldwide. Coals of any rank and high ash content can be fired successfully, but it is essential that the coal quality is very consistent, otherwise flame instability occurs. Pf firing is also used for cement kilns and other large-scale industrial furnaces.

In recent years, there have been developments to use pf as a means of converting existing oil-fired boilers to coal. Hamworthy have developed a system in which pf is fired with oil to provide flame stabilisation. It remains to be seen whether or not pf can be marketed at an economic price to make conversions worthwhile. Other options under development are to provide the pf in the form of an oil or water slurry, with stabilising agents to prevent settling out, so that it can be stored in existing oil tanks. An important consideration with pf is the need to achieve a high collection efficiency of the fine fly ash, and the cost of this may prove excessive in the context of a small boiler conversion.

All of the conventional firing systems must be optimised to suit the particular coal which is being used and it is necessary to make adjustments when the coal is changed if boiler efficiency is to be maintained. A second disadvantage is that, in most conventional systems, the combustion temperature is above the ash fusion point, so that molten ash droplets may be carried into the boiler tube bank and cause fouling. This is particularly the case for pf firing and spreader stokers.

A second cause of boiler fouling is that alkali metal salts are distilled from the ash at above 1000°C and then recondense on to boiler surfaces. The extent of this depends on the coal's sodium content, which is related to the more readily measured chlorine content. As deposits accumulate in a boiler, heat transfer is reduced and the efficiency fails. It is usually economic to shut down a package boiler every six to twelve weeks for cleaning. The period can be reduced to two weeks for a high-chlorine coal. In larger boilers it is usually economic to use compressed air or steam-jet 'soot blowers' to extend the period between shut-downs.

2.2 Fluidised bed combustion

2.2.1 Principles and advantages

Fluidised bed combustion (fbc) is a relatively new combustion technology which has emerged during the last 20 years. The NCB has played a leading role in its development(3). This method of firing utilises a bed of inert particles, such as ash or silica sand about 1 mm, through which evenly distributed air is passed. At a critical air velocity the upward drag forces on particles are such that particles become suspended in the air stream and are said to be 'fluidised'. In normal operation, with an air supply substantially above this velocity, most of the air passes through the bed as bubbles and the bed has an appearance similar to a boiling liquid. As with a boiling liquid there is a considerable amount of turbulence and this causes rapid mixing of the particles.

To bring a fluidised bed into operation, the temperature of the sand bed is first raised to about 600°C using an auxiliary fuel such as gas. Coal is then fed and burns within the turbulent sand, raising the temperature to the normal operating value of between 800°C and 950°C. Because of the turbulence the coal is rapidly distributed throughout the bed. The coal combustion time is 0.5 to 5 minutes, depending on the coal size, and there is typically between 0.5% and 5% of fuel in the bed, the remainder being the inert material. Because the coal particles remain separate in the bed, the coal rank, which is a measure of the tendency of coal to stick together and form coke, is not significant, and coal of any rank can be fired successfully. Also, coals of high ash and moisture content, previously regarded as unsuitable for combustion, can be used in fbc. However, in the UK it will continue to be economic to supply industrial customers with low-ash washed coals, to minimise coal transport costs. Low grade coals will only be fired immediately adjacent to the mine, except in countries where the coal is of a type such that the ash content cannot be reduced by conventional techniques, e.g. India. For UK washed coals having low ash contents, uncrushed lump coal up to 50mm in size can be fired directly to the bed, without drying or crushing. It will usually be preferable to dry and crush a high-ash coal.

Because of the relatively higher mass flow of air per unit area of grate for fbc in comparison with conventional coal burning equipment, higher specific heat release rates are possible. Still higher heat release rates can be achieved by increasing the pressure in the combustion chamber, providing that the pressure energy can be recovered in a gas turbine (see Section 2.2.4).

Another advantage of fbc is the high rate of heat transfer to cooling surfaces immersed in the fluidised bed. Because up to 50% of the heat released during combustion can be removed by in-bed cooling, fluidised bed boilers can be smaller and hence less expensive than conventional systems. However, this saving is partly offset by the more expensive start-up system(4).

The excellent mixing, with resultant uniform distribution of fuel, gives a near-uniform temperature within the bed, which is controlled automatically within the range 800°C to 950°C. These comparatively low combustion temperatures, much lower than for conventional firing systems, are below ash fusion temperature, eliminating the fouling of boiler surfaces by molten ash and alkali salts common with conventional firing. Additionally absorption of sulphur dioxide can be achieved within the bed by continuous addition of crushed limestone with the coal(5). This captures the sulphur dioxide as calcium sulphate, which is collected with the coal ash. The theoretical addition of limestone is 3.15% for every 1% of sulphur in the coal. The stone cannot be fully utilised and the theoretical addition usually reduces sulphur emission by 50%. A retention efficiency of about 80% can be achieved by increasing the rate to twice theoretical, depending on the stone reactivity and operating conditions. The capital investment to retain sulphur in this way is considerably less than for the wet scrubbing systems needed with conventional firing. Also there is not such a large loss in boiler efficiency arising from sulphur retention. For these reasons, fbc is expected entirely to supersede conventional firing in countries with high sulphur coal and legislation limiting sulphur emission, particularly the USA.

A further environmental advantage is that nitrogen oxides, NO_x, do not form from nitrogen in the combustion air at the low combustion temperature in fbc boilers(6). There is still some NO_x formed from nitrogen in the coal, but emission is considerably less than for pf firing. Techniques have been developed in the USA for further reducing NO_x formation, in fbc, using two-stage combustion, and are available for use in the UK if required. However, the capital cost is increased somewhat.

When firing a washed coal, most of the ash is relatively fine and is carried through the boiler in the combustion gases. It is necessary to provide dust collection equipment to meet clean air requirements. The equipment performance must be somewhat better than with stokers, where most of the ash remains in the grate, but is not so critical as with pf firing. It is expected that high efficiency cyclones will fully meet requirements for smaller boilers. Larger boilers will fire smalls, with a slightly higher ash content than singles, but a smaller percentage emission must be achieved. Bag filters are installed on two NCB prototype boilers and have achieved dust emission levels which are well below required levels. However bag filters are expensive and it is expected that a combination of cyclones together with a bag filter for a proportion of the gas flow will prove to be the most economic technique to meet requirements.

2.2.2 Shallow bed technology – industrial boilers

The initial work on fbc during the 1960's was concerned with developing an alternative to pf firing for power generation, because this was the main long-term market for coal envisaged at that time. The system was intended for a part-washed or un-washed coal, with an ash content of 20% and above, and the technology which developed involved crushing the coal and firing it in a bed about 0.6 to 1 m deep in a tall combustion chamber. This system would still be used for high ash coals in power station boilers, but it is inappropriate as an alternative to stoker firing of washed coals, because of the cost of coal crushing and the high fan power associated with the deep bed.

When the NCB recognised in 1972 that coal would again become economic as a fuel for industry, a new development programme was initiated to adapt fbc to make it more suited to industrial requirements(3). Preliminary tests showed that the standard commercial grades of washed coal, singles and smalls, could be fired directly to the bed without any on-site preparation. Furthermore, the combustion performance was improved in comparison with crushed coals and it was possible to reduce the bed depth to about 0.15 m static, i.e. about 0.3 m fluidised. An acceptable combustion efficiency was achieved with singles coal within a chamber height of 1 m, but a taller chamber and grit refiring was necessary with smalls. These tests were followed by the operation of a small prototype boiler at the Coal Research Establishment, commissioned in 1974. The expertise and performance data from this boiler and associated test unit were used to design four demonstration prototype boilers, installed at field trial sites. Three of these were shell boilers(7), which were designed in 1976, commissioned in 1977/78 and are now fully meeting site heating requirements. The fourth was a 30 MW water tube boiler, commissioned in 1981. These prototypes have led to commercial designs of fbc boilers in collaboration with several manufacturers, and a number of these units are already in use at industrial sites. Other manufacturers, recognising the advantage of fbc demonstrated by the NCB, initiated independent development programmes and are also offering fbc boilers on a commercial basis.

A vertical shell boiler offers the most appropriate design for fbc for outputs up to about 5 MW (Figure 2). Two of the NCB prototypes were of this type, both rated at 2.5 MW, one for steam and the other for hot water. The success of these led to the commercial designs of EMS Thermplant Ltd, Wallsend Slipway Engineers Ltd and Allied Boilers Ltd. Eight vertical fbc boilers are now in use at industrial and horticultural sites, providing a high level of amenity and reliability, and further orders are expected.

Horizontal shell boilers, though in more common use, are difficult to adapt to fbc since the headroom available in the conventional cylindrical fire tube is limited to, at most, 1.5 m. Nevertheless, four UK manufacturers, NEI Cochran, Danks of Netherton, Energy Equipment and Thorn EMI Energy Developments (formerly GWB Parkinson Cowan), have designed fbc systems to fit within the fire tube. All four have successfully demonstrated the operation of prototypes and commercial versions have been supplied to clients, including NCB mines, by NEI Cochran and Energy Equipment.

An alternative approach is to use a modified horizontal shell boiler design in order to provide increased height for the combustion chamber. The traditional method of doing this is to use locomotive-type construction (Figure 3). The suitability of this design concept for fbc was demonstrated by an NCB prototype, a 10 MW boiler at Newcastle under Lyme, commissioned in 1978. Locomotive-type construction is used by the NCB's licensee in the USA, the Johnson Boiler Co., Ferrysburg, Michigan, which has supplied 15 fbc boilers with outputs in the range 1-15 MW. In the UK, Energy Equipment are offering a locomotive-type design for outputs up to 18 MW. Novel designs for fbc horizontal shells have been devised by Allied Boilers and Wallsend Slipway. Allied Boilers have supplied a 4.5 MW unit to a factory in Huddersfield, which is operating to meet site requirements, and have subsequently received an order for a 7.5 MW version. Following the successful operation of a 5 MW prototype of the Wallsend design at the NCB Coal Research Establishment, commercial orders have been received for one 1.5 MW and two 8 MW boilers.

Water tube construction is used for outputs above 20 MW and also for smaller boilers producing high pressure steam. An existing 13.5 MW water tube boiler was successfully converted to fbc in 1975 by Babcock Power Ltd using the NCB's crushed coal/deep bed technology under licence. To demonstrate a purpose-designed fbc water tube boiler, the NCB sponsored design and manufacture of a 30 MW unit for superheated steam, which was commissioned at British Steel Corporation's River Don Works, Sheffield, in 1981. The NCB has also collaborated with Gibson Wells Ltd to design a fbc version of their modular packaged water-tube boiler (Figure 4). Units of 15 MW and 7.5 MW are nearing completion at Ambergate, Derbyshire and Bradford, Yorkshire, respectively. In addition to these UK developments, there are a number of demonstration fbc water tube boilers in the USA and Germany and commercial orders are being received by the manufacturers. These units can feed limestone for sulphur retention.

For outputs up to 30 MW and steam pressures to 35 bar, Babcock Power Ltd have developed a composite boiler design, incorporating a water-tube combustion chamber and a shell and tube convection section, arranged in the geometry of a locomotive-type boiler. A fbc version has been designed in collaboration with the NCB and a 4.5 MW prototype has been successfully demonstrated at the Coal Research Establishment (Figure 5). A commercial order has been received for a 15 MW unit and further orders are expected.

All of these various fbc boilers have automatic start-up and load following and those at commercial sites have proved fully able to meet the lead demand placed on them. They have demonstrated that tube fouling is minimal, enabling boilers to be operated for up to a year without loss of efficiency. It is expected that fbc boilers will play a major role in regaining coal's share of the industrial boiler market.

2.2.3 Drying and Heating applications

Development of fluidised bed furnaces for the production of hot gas for industrial and agricultural drying started in 1974. In such furnaces all the heat released during combustion is removed from the shallow bed by hot combustion gases leaving the bed at up to 950°C. Initially development concentrated on applications where the hot combustion gases are used for direct contact drying and where contamination of the product by small amounts of ash is tolerable (Figure 6)(8). The first application was in drying grass to produce high protein animal feed. Following the successful operation of NCB 2 MW and 6 MW prototypes, five 5 MW fbc hot gas furnaces, designed and manufacturerd by GP Worsley in collaboration with the NCB, were installed to convert existing grass dryers from oil firing in the period 1977/78. With reliable operation demonstrated in over 25,000 operating hours the GP Worsley furnace range is being extended and applied to other products. A 15 MW furnace to supply hot gas for clay drying has been operated successfully at Ketton Cement, since 1980. Subsequently GPW have supplied an 18 MW coal fired furnace to Denmark for chalk drying, a 7.5 MW furnace to Amey Roadstone for stone drying and heating, and furnaces of 2 MW, 6 MW and two of 10 MW for coal drying.

Fbc hot gas furnaces are also available from Energy Equipment, who have supplied units of 9 MW and 16 MW for grass drying.

For products dried by clean hot gas, currently produced by firing natural gas or distillate oil, it is necessary to use a coal-fired air heater. A design incorporating a ceramic heat exchanger immersed in the bed is being developed by the NCB in collaboration with Encomech Engineering Services. Following the successful operation of a 200 kW prototype, a 1.8 MW unit is being installed at the Bass Maltings, Mirfield, Yorkshire.

To convert most industrial thermal processes, other than drying, to coal will inevitably require some redesign. An example of this is a prototype fbc gypsum calciner, which has demonstrated a substantial improvement in thermal efficiency in comparison with conventional designs. A larger commercial version is now being designed.

2.2.4 Electricity generation by fbc

In the UK 70% of current coal output is used for electricity generation in pulverised fuel fired power stations. Although it is expected that nuclear power will provide an increasing proportion of the base load electricity supply, it is expected that new coal fired stations will be required to provide mid-merit and peak load supplies. Some of these new units may well be of a smaller scale than current power stations, located near cities so that the reject heat can be utilised. Fbc will provide an environmentally acceptable combustion system for this new generation of installations.

Scaled-up versions of industrial fbc boilers can be considered for this duty. To demonstrate this, the Tennessee Valley Authority and the US Electric Power Research Institute have sponsored the manufacture of a 20 MW (electrical) prototype installation in Kentucky, incorporating a fbc boiler with a thermal output of 80 MW. This is scheduled for commissioning in 1982 and is expected to lead to the manufacture of a 200 MW (electrical) demonstration plant.

Operation of the fbc unit at elevated pressure gives a prospect of increasing the efficiency of steam power generation by utilising the hot combustion gases to drive a gas turbine. This is expected to be possible because alkali metal salts, which would condense on turbine blades with conventional coal firing (cf.boiler fouling), are not volatilised from the ash in fluidised combustion. The NCB initiated work on pressurised fbc in 1969 using a 2 MW unit, and this demonstrated that static blades in the hot gas stream were not subject to excessive corrosion or erosion. Subsequently, this unit has been used to obtain detailed information on combustion, heat transfer and emission control at operating pressures up to 6 bar.

To demonstrate pressurised fbc on a larger scale, an 80 MW facility has been built in the UK jointly financed with the US and Germany. It was commissioned in 1980 and is being used, initially without a turbine, to study scale-up of combustion, heat transfer and emission control. At the same time, alternative gas cleaning devices to attain the low dust loading necessary for a turbine will be assessed. In parallel with this programme, gas turbines will be operated in the US and Germany using cleaned fbc cumbustion gases diluted with air heated in tube banks in a fluidised bed. Subsequently, a turbine will be added to the Grimethorpe unit. It is expected that pressurised fbc will lead to a fuel saving in power generation of more than 6%.

3. Coal Handling

3.1 Delivery

Delivery to power stations and other large users is mostly by rail, using permanently coupled trains. Rapid loading and discharge systems have been developed with trains forming a 'merrygoround'. About 5% of coal output is transported from mines in the north east to power stations in the south east by sea.

Coal for domestic and most industrial use is taken to private distribution companies, either directly by road or rail or via strategically located storing depots. The distribution companies then transport coal to the user by road. Three types of delivery vehicles are available: tipper lorry, conveyor lorry and pneumatic delivery lorry. Because of their versatility and relatively low operating and maintenance cost, tipping lorries are the most economical. Conveyor lorries incorporate a hydraulically driven belt conveyor located at the back of the vehicle which can swing through 180° and deliver coal to a height of 2.8 m, thus providing greater flexibility than the tipper. Pneumatic delivery lorries use a positive displacement blower to provide conveying air, enabling the coal to be transported, via 125 mm diameter flexible pipe, to storage hoppers up to 40 m from the vehicle. This method is particularly suitable for the smaller consumer because it can deliver coal to a service hopper from where it can flow by gravity to the boiler.

A novel method of delivery currently being evaluated is supplying coal in closed containers. Specialised unloading and coal extraction systems are required at the customer's premises but the cost of this should be offset by improved vehicle utilisation. Reduction of site contamination makes this an environmentally acceptable method.

3.2 Reception and storage

The conventional method for receiving coal at a site is for it to be discharged from the rail track or tipper lorry into a reception bunker below ground. From this bunker the coal is conveyed, mechanically or pneumatically, either to the point of use or to medium or long term storage(9). At smaller industrial sites, the reception bunker itself forms a significant part of the on-site storage. Boiler feed hoppers are usually positioned above the boiler so that the coal can flow by gravity. The hopper capacity must be sufficient to ensure continuity of boiler operation in the event of a conveyor system breakdown. This was traditionally at least 24 hours' supply with mechanical coal conveying but can now be substantially less with more readily repaired pneumatic systems. Medium term coal storage, for up to a week's operation, can also be stored in high level bunkers. Longer term storage is conveniently in open stockpiles: various stock reclamation systems are available, depending on the scale of operations. However, coal storage space is often no longer available at many industrial sites and silos are being used increasingly for medium and long-term storage. Capacities are typically 100 to 500 tonnes although units up to 1000 tonnes are available.

A new development in coal reception for industrial sites is for the lorry to tip the coal onto a platform, which is then tipped to feed the conveying system. This avoids the expense of excavating a reception hopper below ground.

Correct design of bunkers, hoppers and silos is essential to ensure that difficulties are not encountered due to blockage, inconsistent flow or segregation of size components. The minimum angle of inclination of the cone base must be specified, depending on the flow properties of the particular coal; typically 70° to the horizontal for small coal, less for singles. To ensure the flow of smalls coals, bunkers and hoppers are preferably lined with non-corroding smooth-surface materials, such as glass or high density polyethylene. Also proprietary vibrating devices are available to promote coal flow.

In all situations where coal is stored, care must be taken to avoid spontaneous combustion. If air is present, coal will oxidise slowly at ambient temperature, giving out heat, and if the heat is not dissipated then the temperature will gradually rise and the rate of combustion will increase. There are two approaches to preventing this. In the case of singles coal in a hopper or silo, it is preferable to ensure good ventilation so that the air carries away any heat generated. In the case of a ground stock pile, and also for smalls coal in a hopper, the usual technique is to prevent access of air into the coal, e.g. by compacting the surface of the stockpile or even coating the pile with a layer of bitumen.

3.3 Conveying systems

Conventional mechanical coal conveying systems such as belt elevators, bucket elevators and drag link conveyors are fairly expensive to install, require regular maintenance to ensure reliability and are prone to blockage when conveying difficult-to-handle coals such as wet smalls with a high content of fines(9). Screw conveyors provide an inexpensive means of handling singles coal in small boilerhouses but can cause a certain amount of degradation. All these systems have the disavantage that they cannot accommodate a horizontal bend, so multiple units must be used if the site layout is difficult.

A modern alternative to these mechanical systems is pneumatic conveying, which has competitive capital cost and low maintenance requirements(9). Two types of pneumatic conveying are available: dense and dilute phase. Dense phase systems operate at solids to air mass ratios in excess of 40:1, require compressed air and are particularly suitable for smalls. By contrast dilute phase systems, which can use positive pressure or suction, operate at ratios below 20:1, require relatively low pressure air as supplied by a fan, and are at present limited to conveying singles.

In the UK dense phase conveying equipment suitable for coal transport is supplied by four commercial companies: Macawber, Send-air, Sturtevant and Neu Engineering and a typical example is shown in Fig. 7. Coal is gravity fed from the bunker into a pressure vessel below and a valve shuts off the flow when it is full. Inflatable rubber seals around the valve are activated to make it airtight before compressed air is supplied to the top of the vessel, forcing the coal out into the conveying pipe as a plug several metres long. The plug of coal is blown through the pipe to the boiler feed hopper before the cycle is repeated.

An example of a dilute phase system is a suction nozzle, shown in Figure 8, recently developed by the NCB for singles. The nozzle consists of two vertically mounted concentric tubes with the top of the inner tube connected to the conveying pipe and the outer tube forming an annulus. A suction fan draws air through the conveying pipe, inner pipe and annulus, entraining coal at the end of the nozzle. A cyclone above the boiler feed hopper is used to separate the coal from the air, prior to the fan. Several boilers can be supplied by incorporating diverting 'Y' valves in the pipework. This conveying system has the advantage that, apart from the fan, there are no moving parts.

3.4 Feeding systems

Feeding equipment is required to supply the combustor with coal at the rate demanded by the control system to maintain boiler steam pressure or water temperature.

With stoker firing, the feed system forms an integral part of the stoker. A screw conveyor is used for underfeed stokers and rotary valve or ram for coking stokers. Chaingrate stokers are self feeding by means of the variable-speed grate. Screw feeders or rotary valves are used to feed singles to fbc boilers and furnaces, but can become blocked with the most difficult smalls. One alternative is to use a short drag-link conveyor with variable speed drive, as used for feeding large spreader stokers.

3.5 Coal/liquid mixtures

In recent years there has been considerable interest in the USA and elsewhere in producing a 'liquid' fuel by pulverising coal and mixing it with oil or water, together with additives to prevent settling out. The incentive is to provide a means of firing coal in existing boilers, designed for oil or gas, utilising the oil tanks for storage. Inevitably there would have to be some boiler down-rating because erosion by ash particles is likely at the high gas velocities used in boilers for clean fuels. Also, there would be modifications to the fuel handling system and burners, to accommodate particulates, and a fly-ash collector would be required to meet dust emission requirements.

The initial interest was in coal oil mixtures, COM, containing up to 60% of coal by weight, representing about 40% of the heat content. By using a specially prepared low-ash coal, the problems of conversion are minimised, but savings arise only from replacing 40% of the oil. It is now generally considered that COM will not be economic at the price differential between oil and coal in Europe, but it may be used elsewhere if low cost coal is available. Development work on COM has been carried out in the UK by BP and Shell.

More recently, attention has turned to using a coal water slurry, CWS, as a means of effecting 100% oil replacement. However the problems of conversion are increased and, in addition, there is a loss in boiler efficiency of about 4% because of the fuel's high water content (40-50%). As with COM, it is preferable to use a coal with minimum ash content, and this involves a secondary ash separation stage after the coal is pulverised, e.g. by froth flotation. Thus the coal in a CWS will be substantially more expensive than lump coal as fired in a stoker or fbc, and somewhat more expensive than pulverised coal. Even if the preparation and firing of CWS becomes commercially possible, it may prove preferable to replace oil boilers before the end of their useful life rather than fire CWS in them, particularly in the case of low-cost shell boilers.

4. Ash Handling

The ash content of UK washed coals is in the range 5 to 10%: the part-washed coals supplied to CEGB and other very large users contain about 18% ash. The nature of the ash after combustion, and the method for collecting and handling it, is dependent on the firing method. However, in most cases, coal ash will be dusty and potentially abrasive.

With stoker firing most of the ash remains on the grate: a small proportion is entrained in the combustion gas but dust emission standards can be met with a simple cyclone. With a moving grate, ash will fall off the end into the ash handling system but, with a static grate or conventional underfeed stoker, it must be transferred manually from the boiler into the ash system. Pneumatic conveying is usually the preferred method of conveying ash from the boiler to the storage hopper. Dense or dilute phase can be used, although there is a preference for suction dilute phase because it ensures that there is no dust emission through holes eroded in the conveying pipe. Mechanical conveying systems generally suffer from excessive wear due to ash ingress into moving components, although conveyor belts submerged in water are sometimes appropriate. Water sluice systems are under development. For stokers in which clinkers may form, such as static grates, it is necessary to install a clinker crusher before the conveying system.

In the case of fbc and pf firing, most of the ash is entrained in the combustion gases, although it is still usually necessary to make provision to remove ash from the combustion chamber. The ash entrained from fbc is somewhat less fine than that from pf and is thus collected more readily. High efficiency cyclones are sufficient to meet the emission standards for smaller boilers, but are not adequate for the stricter standards applying to larger boilers. Bag filters, or a lower cost combination of cyclones and bag filters, are used in larger industrial boilers and are extremely effective, albeit somewhat expensive. Electrostatic precipitators are used in power station boilers.

5. Conclusions

The realisation that the availability of oil and gas will become increasingly limited, leading to higher prices, has resulted in a resurgence of interest in coal, particularly as a fuel for industrial applications. This interest is stimulating improvements in traditional coal combustion technology as well as the development and commercialisation of new technologies such as fluidised bed combustion. The amenity of coal is being improved by increasing use of pneumatic conveying, with consequent reduction in capital cost and maintenance requirements. Increases in reliability and automation, including automatic ignition, have been achieved in traditional firing equipment. Fluidised bed systems are providing a high level of amenity and reliability, while maintaining high efficiency for extended period by virtually eliminating boiler fouling. Modern coal firing readily meets the requirements of UK Clean Air Acts and techniques exist to further reduce emissions, albeit with an increase in the capital and operating costs.

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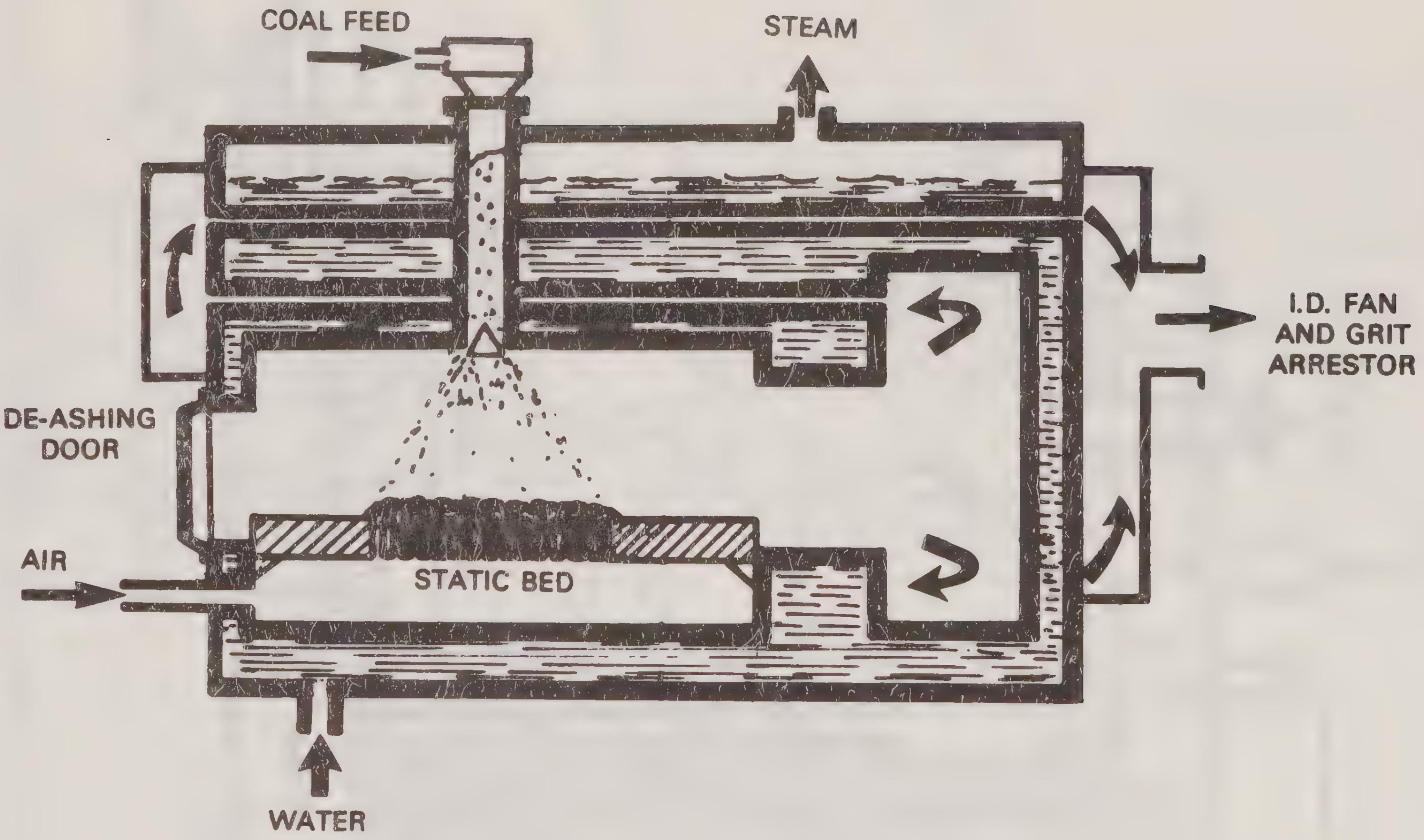

Fig. 1 Vekos Powermaster boiler with static grate

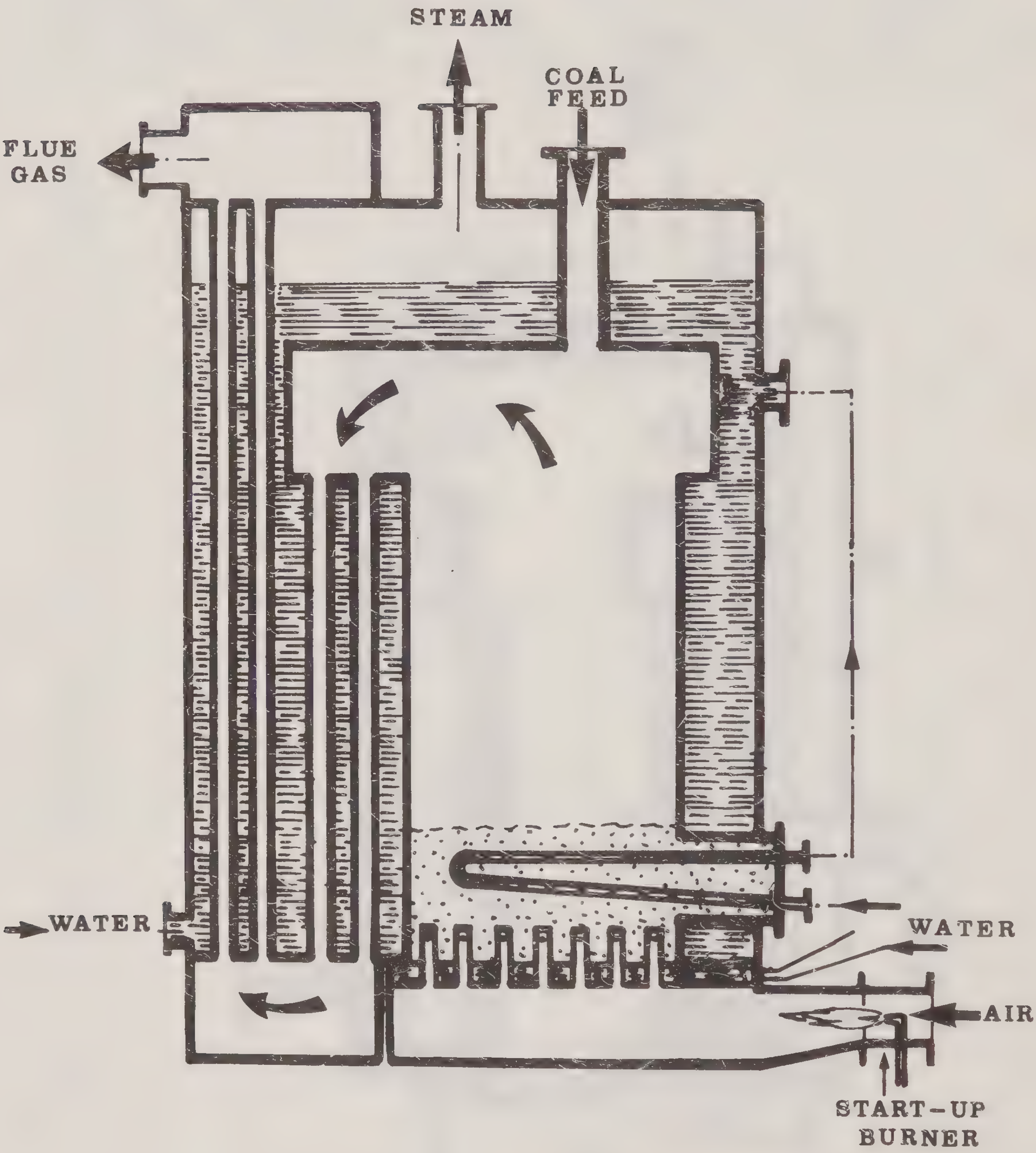

Fig. 2 EMS Thermplant vertical shell fbc boiler

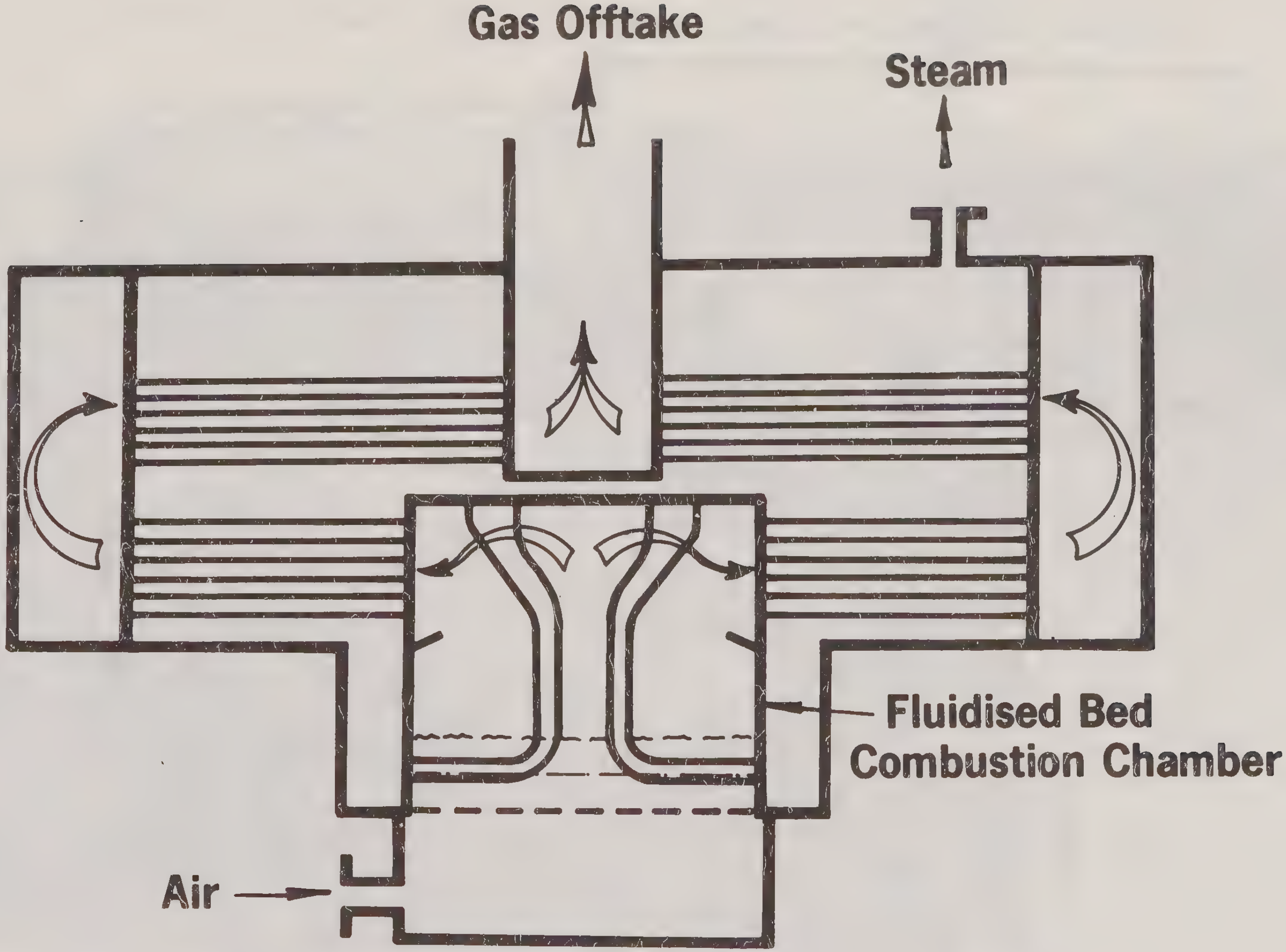

Fig. 3 NCB locomotive-type fbc boiler
(others have combustion chamber at one end)

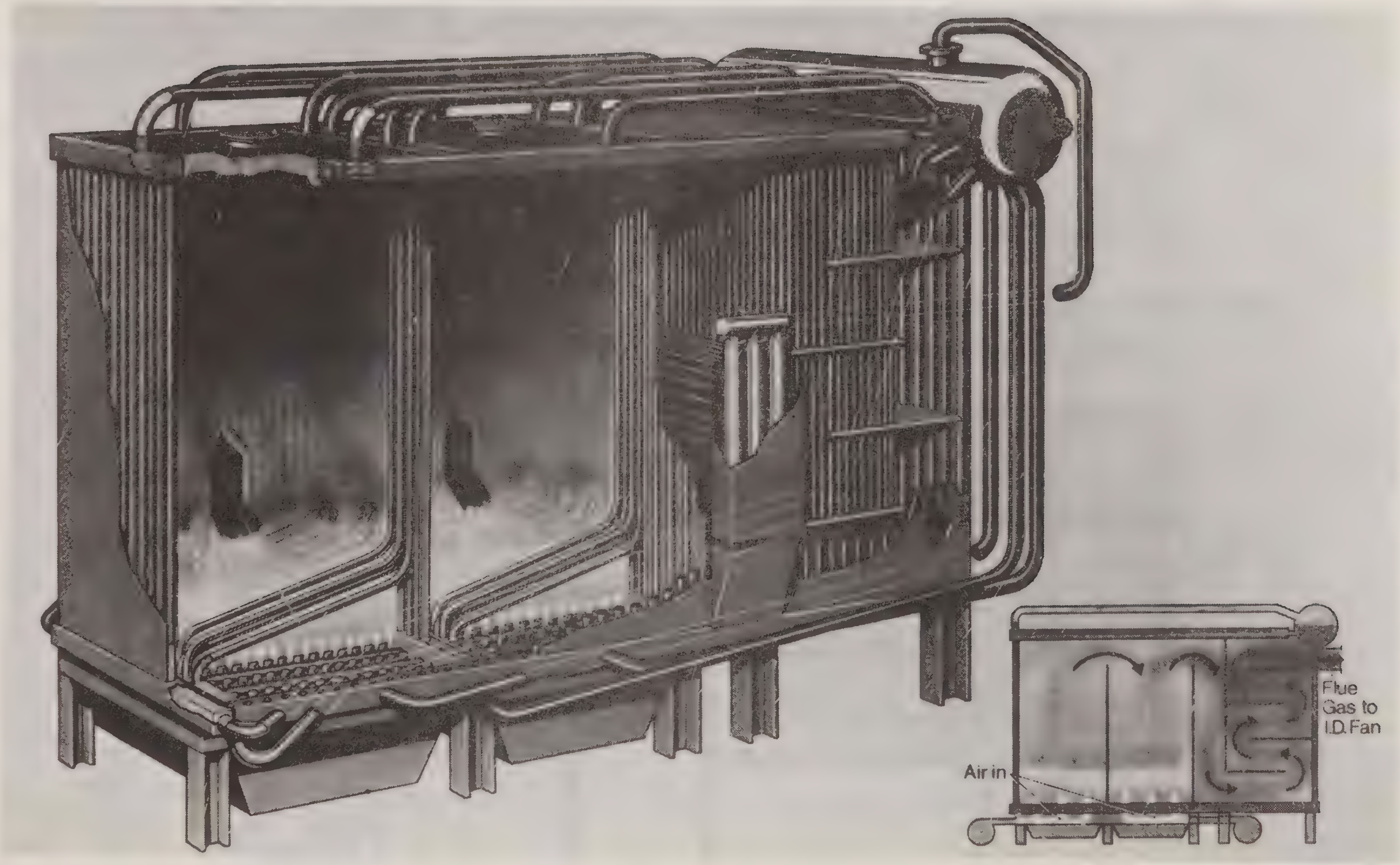

Fig. 4 Gibson Wells modular water-tube fbc boiler

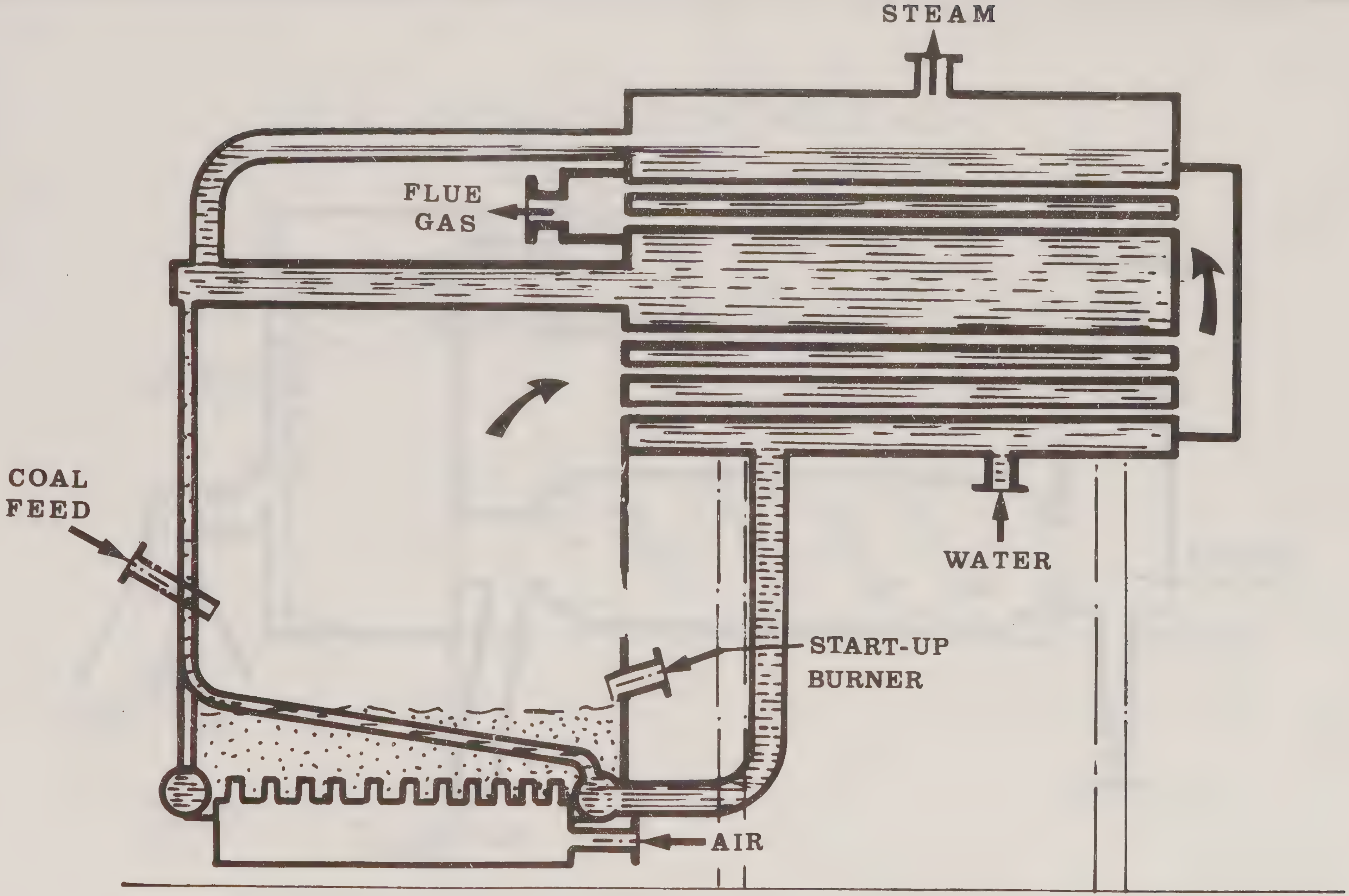

Fig. 5 Babcock Power composite water-tube/shell fbc boiler

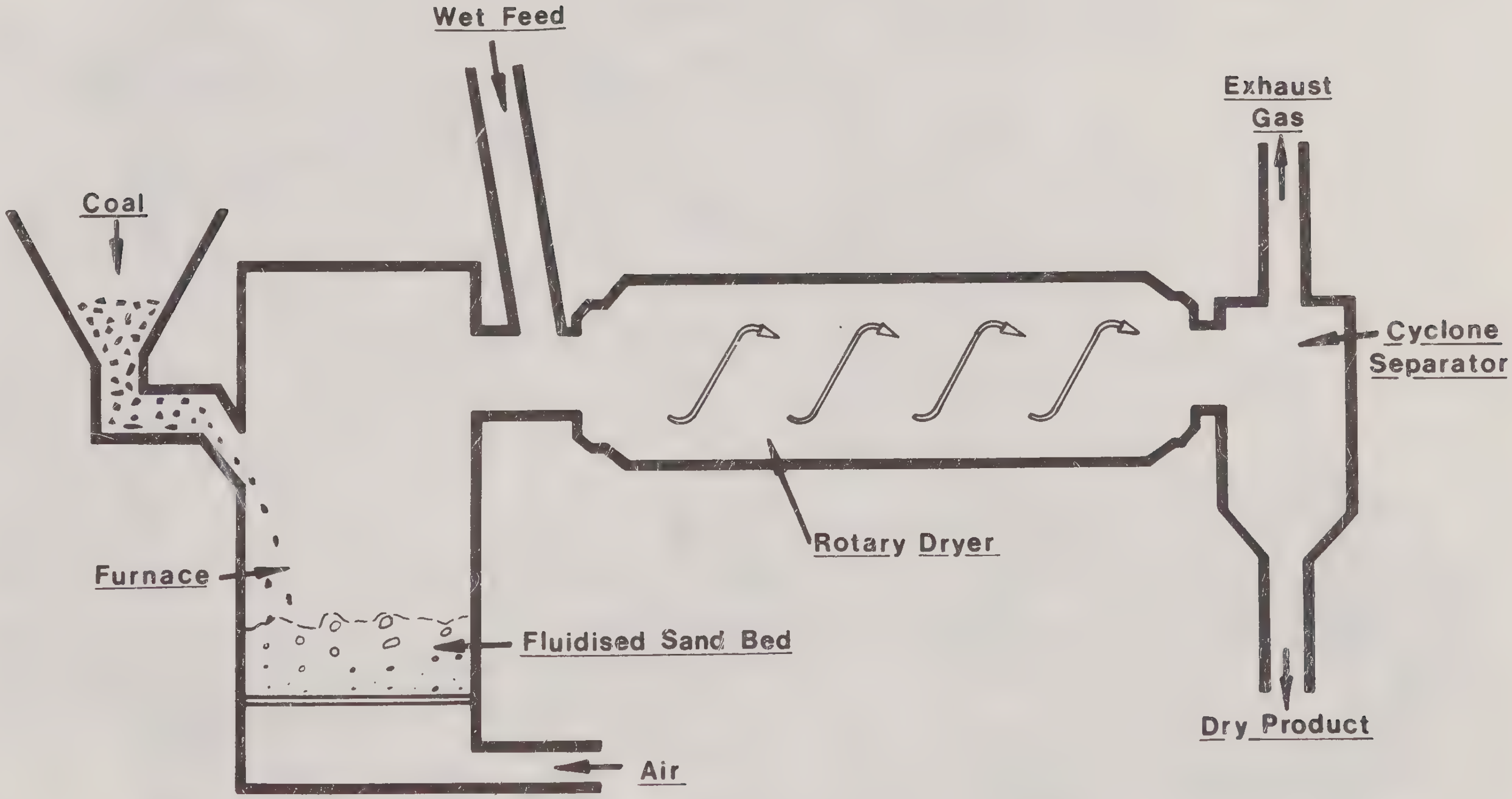

Fig. 6 Fluidised bed fired drying kiln

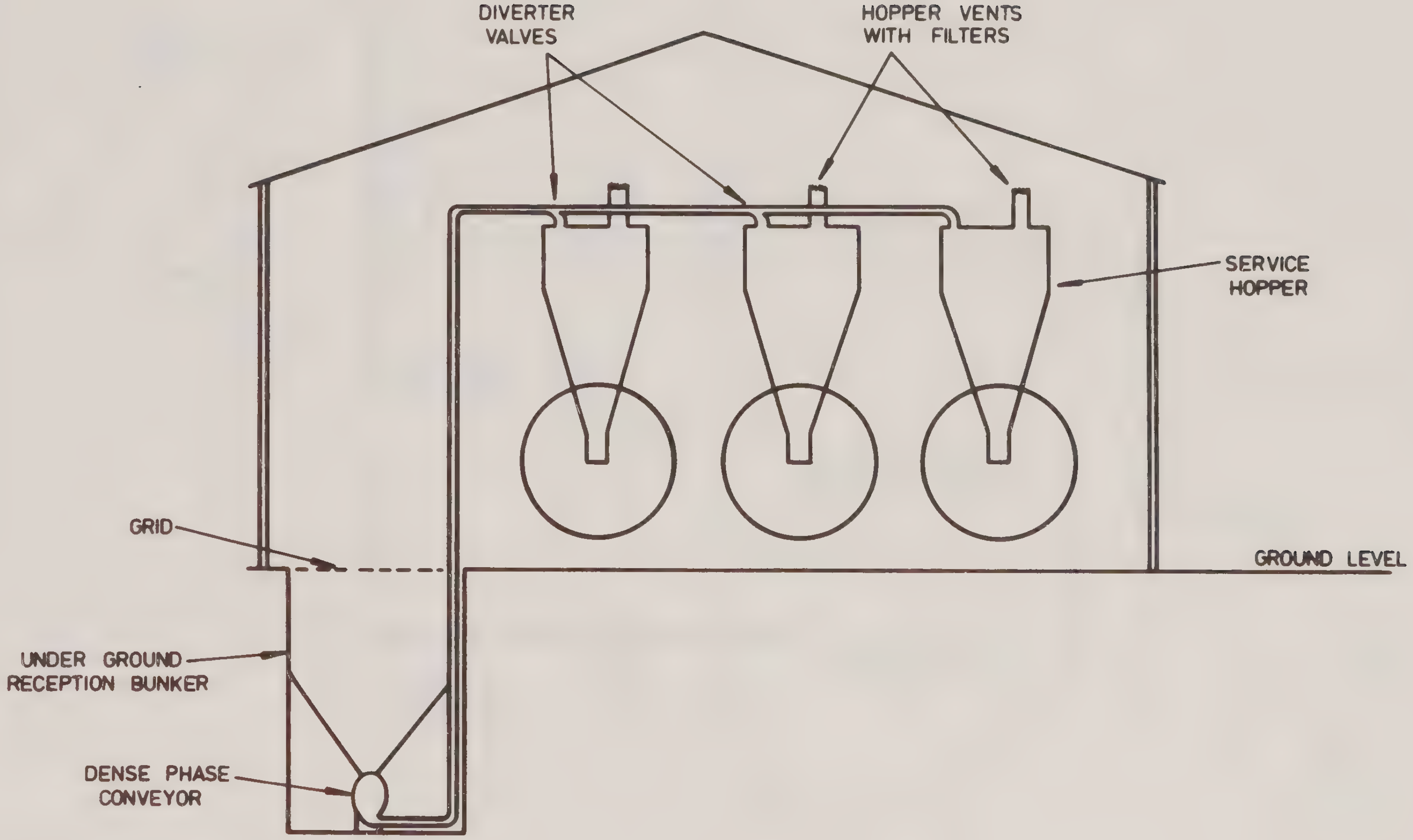

Fig. 7 Dense phase coal conveying system

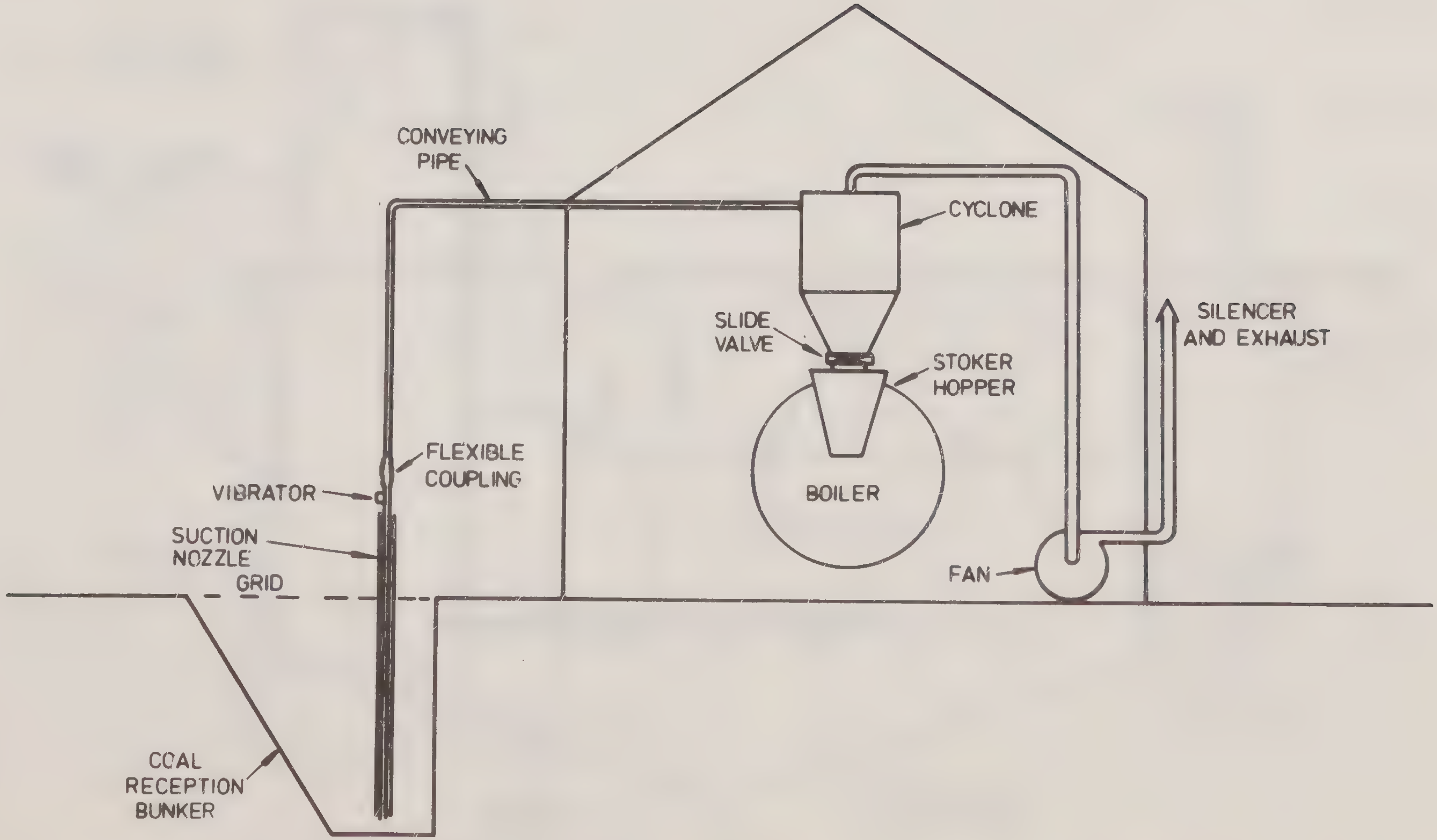

Fig. 8 Dilute phase coal conveying system (suction)

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PROGRESS IN MEETING THE EC DIRECTIVE WITH SPECIFIC REFERENCE TO SMOKE CONTROL

By

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1. INTRODUCTION

Before proceeding, it is worth while clarifying the title of the present paper. The Directive referred to is, of course, the European Community (EC) Directive of July 15th 1980 on air quality limit values and guide values for sulphur dioxide (SO_2) and suspended particulates (hereafter referred to as smoke)$^{(1)}$. This clarification is made because although the smoke and SO_2 Directive was the first to be adopted on the subject of air quality, it will probably not be the last. A further Directive dealing with a limit value for concentrations of lead in air is at an advanced stage within the Community, and there is a draft Directive on NO_2 air quality under discussion. Furthermore, the proposed Third Environment Action Programme of the EC states that the Commission will continue its efforts to establish air quality standards.

This paper will consist of three sections. First, a brief review of the provisions of the Directive will be given. Second, the historial trends in breaches of the Directive will be discussed in terms of the progress already achieved in smoke control and downward trends in smoke concentrations in the UK over the past twenty years or so. Third, without discussing individual areas, some indications will be given of the reductions in smoke concentrations which may be achieved by smoke control in areas typical of those already at risk of exceeding or actually in breach of the Directive limit values.

2. THE EC DIRECTIVE ON SMOKE AND SO_2

The Directive has been in existence for roughly two years at the time of writing, and the contents have become very familiar to those directly concerned with its assessment and implementation both technically and at Central and Local Government levels. However, it is probably useful at this stage to review some of the main points of the Directive and this is done briefly in this section. The implications for air quality control in the UK and the implementation of and compliance with the Directive will be discussed in a later section.

The Directive sets air quality limit values for ground level concentrations of smoke, measured either gravimetrically or as black smoke, and SO_2, which are based primarily on the World Health Organization findings regarding the dose/effect relationships of these pollutants. In that adverse health effects due to one pollutant were found to be enhanced by elevated concentrations of the other, the limit values have been expressed in a combined sense, so that if smoke concentrations exceed a "trigger" value, a more stringent SO_2 limit must be met. The limit values are based on 24-hour average concentrations and are expressed as medians of annual and winter periods and as 98th percentiles over an annual period. The Directive prescribes mandatory maximum values (limit values) for the ground level concentrations to be met throughout the Community by 1 April 1983. Derogations may be permitted for specific areas that exceed the limit values provided that a Member State demonstrates that it is taking the necessary measures to bring pollution concentrations below the limit values as quickly as possible and by 1 April 1993 at the latest. The Directive also provides a non-mandatory, lower set of values (guide values) which are intended to serve as reference points for the longer term inprovement of air quality and for the setting of targets in special zones if necessary. The limit values and guide values are reproduced in Table 1. The approximate UK winter average concentrations equivalent to the limit values obtained from a statistical analysis of National Survey data are shown in Table 2.

3. A HISTORICAL ANALYSIS OF SMOKE CONCENTRATIONS IN RELATION TO THE EC DIRECTIVE AND THE EXTENT OF SMOKE CONTROL IN THE UK

3.1 Smoke Concentrations In The UK In Relation To The EC Directive

Over the past few years, the Department of the

Environment (DoE), in conjunction with Warren Spring Laboratory (WSL), has been reviewing results from the former National Survey and fairly detailed assessments have been made of those areas where the concentrations of smoke and SO_2 are at risk of breaching the limit values. A map showing areas at risk and smoke control areas was published by the Department in 1981 and is shown in Figure 1.

This national assessment is being updated and reviewed as more concentration data become available, and discussions with local authorities have been under way for some time to deal in more detail with individual areas. A summary of the general position of the UK in terms of compliance with the Directive and the procedure which DoE will adopt in conjunction with the local authorities is given in Circular 11/81 of the DoE(2). It is not within the scope of this paper to discuss the problems involved with the overall implementation of the Directive or to deal with individual authorities or areas, but rather to concentrate on those aspects concerned primarily with smoke concentrations.

It is now well established that, following the move away from coal as a fuel in domestic use which began in the early 1960's, UK urban smoke concentrations have shown a marked decrease in the past twenty years, to an extent that where the UK urban annual average was 150 μgm^{-3}/in 1960/61 it was 20 μgm^{-3} in/1980/81. This trend is plotted in Figure 2, where also shown are the total UK domestic coal consumption and the cumulative totals of acreage and number of premises covered by smoke control orders. The strong correlation between the increase in smoke control and decrease in domestic coal consumption might suggest a stronger causal link than was actually the case. It is very probable that despite the onset of smoke control a certain fraction of the population would have moved away from the use of coal to the more convenient oil and gas fuels. Nonetheless it is reasonable to conclude that this implementation of smoke control programmes throughout the UK has been the major cause of the reduction in domestic coal consumption over the past twenty or so years. The high correlation between domestic coal consumption and smoke concentrations over this period is indeed the result of a causal relationship particularly in the earlier part of the period, although where concentrations have decreased to relatively low levels in recent years, the proportionate contribution from other sources, notably motor vehicles, will now of course be larger.

It is interesting to analyse the historical smoke and SO_2 data, back to the early 1960's before the marked reduction in coal consumption, in terms of the EC Directive limit values. In view of the reasonably uniform downward trend of both smoke and SO_2 concentrations (as UK averages) since 1960, the analysis has not been carried out for every year but only for a sufficient number of years to indicate the general trend and the results are shown in Figure 3.

The height of each column measures the total number of sites in the UK which breached any of the limit values shown in Table 1, for the particular pollution year beginning in April of the year shown on the x axis. It can be seen from the figure that the total number of sites breaching the limit values has fallen broadly in line with the decrease in smoke concentrations. In 1962/63 for example the number of sites breaching was 925 which was 98% of all the sites with data, while in 1979/80 the number was 58 or 6% of all sites. The relationship between the frequency distributions of UK sites and the ratio of the 98th percentile to median limit values in the Directive is such that, for the UK sites, the 98th percentile limit values are in general the more stringent. To demonstrate this, particularly in relation to the importance of smoke concentrations in determining breaches of the limit values, the data has been analysed to identify the number of sites which breach the 98th percentile limit value for smoke alone, i.e. regardless of the corresponding SO_2 concentration. This value is 213 μgm^{-3} in terms of the British Standard calibration curve as used in the UK. The numbers of such sites are also shown in Figure 3 from which it is clear that in the early 1960's the breaches of the limit values were due almost entirely to elevated smoke concentrations. In the mid-to late 1960's and in the 1970's coal consumption and hence low level smoke emissions declined. So too did low and medium level SO_2 emissions(3) and the total number of breaches of the limit values declined. During this period the fraction of total breaches due entirely to elevated smoke concentrations (i.e. those sites with annual 98th percentiles of smoke $> 213\ \mu gm^{-3}$) also declined and the fraction due to other causes increased. Most of these other breaches ($\sim$ 20% of all breaches in 1979/80), shown by the shaded sections in Figure 3, occur because the 98th percentile smoke "trigger" value of 128 μgm^{-3} is exceeded so that the more stringent SO_2 limit value applies.

Notwithstanding this trend it is clear from Figure 3 that where breaches occur, the extension of smoke control with a reduction in low level smoke emissions is likely to be the most effective way of ensuring compliance with the limit values. Although not presented here, a more detailed analysis reveals that the majority of sites remaining in breach in the period since 1977 are in areas of relatively high coal consumption and where, overall, smoke control is not yet complete. It is for these reasons that Circular 11/81 identified the introduction and extension of smoke control as the primary method for reducing concentrations to comply with the limit values.

It is worth commenting on the results for 1980/1 and 1981/2, the latter at this stage being provisional since full quality assurance checks have not been carried out at the time of writing. The number of sites breaching in 1980/1 showed a marked decrease from 58 in the previous year to 11, while the provisional estimate for 1981/2 is 81. Since a major proportion of the ground level concentrations of smoke and SO_2 in the areas breaching the limit values arises from space heating, the broad features of these results may be rationalised for the UK as a whole as a combination of the continuing downward trend in emissions and concentrations modified by a slightly warmer than average winter in 1980/1 and a much colder than average winter in 1981/2 leading to decreased and increased emission respectively. It is probably not justified to analyse these year to year variations any further than this at a national level. Local variations could be much more important in affecting individual sites and the changes in emission patterns and meteorology would have to be analysed at the local level to draw meaningful conclusions. It is worth pointing out, however, that in December 1981 (in pollution year 1981/2), the UK average Degree Days were ~30% higher than the previous 20 year average(9) and in those regions of England and Scotland where smoke concentrations tend to be among the highest, the differences were 40-50%. It is therefore probable that the longer term downward trend in emissions compensated to some extent for 1981/2 meteorological conditions leading to a number of breaches of similar order to those found in the last 1970's.

3.2. The Current Position On Smoke Control In The UK

It is of interest at this stage to assess the extent of smoke control which is still to be carried out. Rather than analysing the situation at individual local authority level, data on smoke control orders in England have been obtained from the most recent National Society for Clean Air Handbook(4), which gives the position on 31 March 1981, and aggregated up to Regional level. These are shown in Table 3 where an indication of the amount of smoke control left in each region is expressed as a percentage of the final acreage when proposed programmes are completed. It is recognized that there are inevitable uncertainties in some of the individual authorities' data in that the final acreage may be uncertain or not decided, but taken overall the figures give a reasonable indication of the remaining areas. The area with the smallest percentage remaining is London, where smoke control programmes have been complete or almost complete for some time, while those Regions with the largest percentage of final acreage remaining are Yorkshire and Humberside and the South East, although smoke concentrations in the latter region tend to be low.

It is probably not justified to attempt to draw detailed conclusions from this Table, particularly in comparing one Region with another, but the most significant feature of the data is that most Regions have completed roughly half of the proposed final area of smoke control. From the areas at risk already shown in Figure 1 it can be seen that the majority lie in the North West, Yorkshire and Humberside and East Midlands Regions. It should be noted here that although these areas were identified at a time when the concentration data for 1979/80 was the most recent, it is still the case that the introduction and extension of smoke control represents the most effective means of removing these areas at risk.

4. SMOKE CONTROL AND COMPLIANCE WITH THE DIRECTIVE LIMIT VALUES

It would not be appropriate in a paper such as this to analyse the benefits of introducing or extending smoke control in any particular local authority area. It is also clearly impracticable to perform such an analysis for all those areas of the UK currently considered to be at risk of breaching the Directive Limit values. As illustrations, therefore, of the likely reductions in smoke concentrations resulting from smoke control, some examples based closely on actual situations have been devised.

Ideally, in order to be able to predict the decrease in smoke concentrations arising from any increase in smoke control or fuel pattern changes, it would be necessary to quantify the contributions to ground level concentrations from different source and fuel categories using atmospheric dispersion modelling techniques. Warren Spring Laboratory has been developing and applying these techniques since the early seventies, beginning primarily with a major study in the Forth Valley of Scotland sponsored by the Scottish Development Department (5)(6) and subsequently also for the Department of the Environment, the British Airports Authority (7)(8) and others. One component of these modelling techniques is a simple "box"model, used to calculate the contribution to concentrations from the multiplicity of small low-level emitters typical of residential premises. This simple model is very briefly described in Appendix A and some comparisons between observed and calculated concentrations are given to help readers assess the reliability of the model. Bearing in mind the simplicity of the model and that there are errors in both the estimated emission rates and observed concentrations, the agreement is reasonable. Fuller detils of the modelling techniques are given in reference 4.

The model in Appendix A has been used to calculate estimates of the winter average smoke concentrations which would arise from the combustion of a range of tonnages of coal in areas of different size for a coal consumption rate of 1000 tonnes km^{-2}. The results are shown in Figure 4. It has been assumed that 4% by weight of the coal consumed is emitted as smoke. This is believed to be a typical figure for the more volatile coals in the UK and somewhat lower figures may apply therefore in some areas. Coals mined in South Wales are exceptionally low in volatiles with a smoke emission factor of only about 1.5%, which accounts for the relatively low smoke concentrations observed in South Wales despite the absence of extensive smoke control. It has also been assumed in Figure 4 that the winter average coal consumption rate is 1.35 times the annual average rate(5). The expected average concentrations due to different consumption rates are then obtained pro rata, a consumption of 2000 tonnes km^{-2} for the same size area yields double the concentration as shown in Figure 4, etc.

The first example to be considered is a mining community with no smoke control. Let us assume that the populated area occupies 2.5 km^2 and that it is densely populated with a fairly high annual coal consumption of 10,000 tonnes km^{-2}, (equivalent to a population density of 5000 km^{-2} and a consumption of 1.5 tonnes per head). We will further assume that the community is relatively isolated and that the contribution from road traffic sources within the community is small, so that a reasonable contribution to the winter average smoke concentrations from the "background" and other sources is 20 μgm^{-3}. Using the data in Figure 4, the box model estimate of winter average smoke concentrations is $\sim$ 100 ugm^{-3} so that the total including background is $\sim$ 120 ugm^{-3}. This is consistent with the order of concentrations currently measured in such areas in the UK. If we now assume that the area is completely smoke controlled and that all those who previously burned coal now burn solid smokeless fuel (for which we assume a smoke emission factor of 0.56%), the winter average concentration of smoke becomes $\sim$ 34 ugm^{-3}, which from Table 2 should be sufficient to ensure compliance with the EC Directive limit values, assuming no major increase in SO_2 concentrations occurs independently of the smoke control on domestic sources.

The second type of area considered is a slightly larger community which is, like the first example, situated on a coalfield, where smoke control programmes have been in operation for some years but are not yet complete. A hypothetical arrangement is shown is Figure 5. Let us first of all consider the situation prevailing before any smoke control orders were made, typically in the mid-to late 1960's. The area, which covers 5 km^2, is again assumed to be fairly densely populated with a density of 5,000 inhabitants per km^2 and, before smoke control, an annual coal consumption of 1.5 tonnes per head. The annual consumption for the area was thus 7,500 tonnes km^{-2} on average. It is further assumed that the area is not isolated but is surrounded by similar smaller areas, so that at that time a reasonable value for the background winter average smoke concentration would be $\sim$ 50 μgm^{-3} with the contribution from motor traffic within the town amounting to a further 20 μgm^{-3}. The box model contribution, from Figure 4, is $\sim$100 μgm^{-3}, so that the total winter average smoke concentration is estimated to be 170 μgm^{-3}, a value typical of those measured in such towns in the mid-to late 1960's. Let us now consider the smoke control situation as shown in Figure 5 and, in particular, smoke concentrations in the non-smoke controlled area A1. Assuming consumption patterns in this smaller area have not changed, the box model gives a winter average concentration in A1 of 60 μgm^{-3}.

The contribution of the sources in A2 to concentrations in A1 may also be obtained from the box model if we consider the total area, A1 + A2, i.e. 5 km^2 but omit the sources in A1 from the calculation. If we assume 100% change to smokeless fuel in A2 with an emission factor of 0.56% by weight, the winter average contribution to A1 becomes $100 \times (0.56/4) \times (4/5) = 11$ μgm^{-3}. It is more realistic to assume for a background concentration a lower value than previously, in accordance with the decrease in smoke concentrations over the period considered and a value of 25 μgm^{-3} is assumed, which includes the motor traffic contribution.

The total winter average concentration in A1 is therefore $\sim$ 95 ugm^3 which is broadly typical of the concentrations measured in towns of the type considered in the past several years. If we now wish to predict the decrease in smoke concentrations in A1 after full smoke control, assuming 100% change to smokeless fuel, we simply use Figure 4 on the full area and scale the result by (0.56/4) which gives a contribution of 14 μgm^{-3} from A1 + A2. It is probably pessimistic to assume that the "background" of 25 μgm^{-3} remains the same, since as neighbouring towns become increasingly smoke controlled, this background concentration may decrease. However, assuming a value of 24 μgm^{-3} yields a final total winter average of $\sim$ 40 μgm^{-3} which should result in compliance with the Directive limit values. As the smoke concentrations decrease to approach the 'trigger' values discussed in section 2, the SO_2 concentrations become increasingly important. On direct substitution of coal, the sulphur content of which varies but is on average $\sim$ 1.3%, by smokeless fuel (sulphur content 1%), there is a reduction of up to 30% in the SO_2 contribution from domestic coal. The effect on the total SO_2 concentration will be smaller than this in most towns since domestic sources will probably only account for at most ~ 50% of the SO_2 concentration, the remainder arising from commercial/industrial space heating and process emissions. The effect of smoke control on SO_2 is likely therefore to be small, except in areas where coal is the dominant source of existing SO_2 and where the substitute fuel is gas, which is of course sulphur free. In areas where the domestic coal contribution is large, however, existing concentrations of SO_2 are such that in general the Directive values will probably be met following full smoke control.

5. SUMMARY AND CONCLUSION

This paper has analysed the historical trends in smoke concentrations in the UK in the light of increased smoke control and changing patterns of fuel use. The results of these downward trends in smoke concentrations in terms of the numbers of sites breaching the EC Directive on smoke and SO_2 have also been analysed. The total number of sites in the UK breaching the Directive limit values was 925 in 1962/3 and this had decreased to 58 in 1979/80, and to 11 in 1980/1. In 1981/2, which was characterized by the coldest December of this century(10), the number of sites breaching increased to 81.

An analysis of the type of breach, that is whether elevated concentrations of smoke alone or SO_2 alone or combinations of the two are responsible, reveals that the majority of sites breach because of elevated smoke concentrations. This analysis, together with some estimates of the reductions in smoke concentrations brought about by the introduction or the extension of smoke control programmes, suggests that this is the most effective method in most areas of the UK for ensuring compliance with the limit values contained in the EC Directive.

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TABLE 1 LIMIT VALUES FOR SMOKE AND SULPHUR DIOXIDE IN MICROGRAMMES PER CUBIC METRE

Reference Period	Limit Values for		
	Smoke *	Sulphur dioxide	
Year (Median of daily values)	80 (68)	If smoke less than 40:	120
		If smoke more than 40: (34)	80
Winter (Median of daily values Oct-March)	130(111)	If smoke less than 60:	180
		If smoke more than 60: (51)	130
Year (Peak) (98 percentile of daily values)	250(213)	If smoke less than 150:	350
		If smoke more than 150: (128)	250

GUIDE VALUES FOR SMOKE AND SULPHUR DIOXIDE IN MICROGRAMMES PER CUBIC METRE

Reference Period	Smoke *	Sulphur dioxide
Year (arithmetic mean of daily values)	40 to 60 (34 to 51)	40 to 60
24 hours (daily mean value)	100 to 150 (85 to 128)	100 to 150

*Limit values for smoke as stated in the Directive relate to OECD method: figures in brackets give equivalents for BSI method as used in the National Survey.

TABLE 2 TYPICAL UK WINTER AVERAGE CONCENTRATIONS CORRESPONDING TO EC LIMIT VALUES

EC Limit Value (µg m-3)	UK Typical Equivalent Winter Average (µg m-3)
Smoke	
34 annual median	65
68 annual median	130
51 winter median	65
111 winter median	145
128 98 percentile	45
213 98 percentile	70
SO_2	
80 annual median	110
120 annual median	165
130 winter median	150
180 winter median	210
250 98 percentile	105
350 98 percentile	145

TABLE 3 REGIONAL STATUS OF SMOKE CONTROL IN ENGLAND ON MARCH 31st 1981

Region	Final Acreage	Acreage in Operation	Percentage of Final Acreage Remaining
Northern	291830	133725	54
North West	669628	447664	33
Yorkshire and Humberside	989615	343892	65
West Midlands	380754	184993	51
East Midlands	259396	143491	45
South East	327161	140175	57
London	384082	355661	7

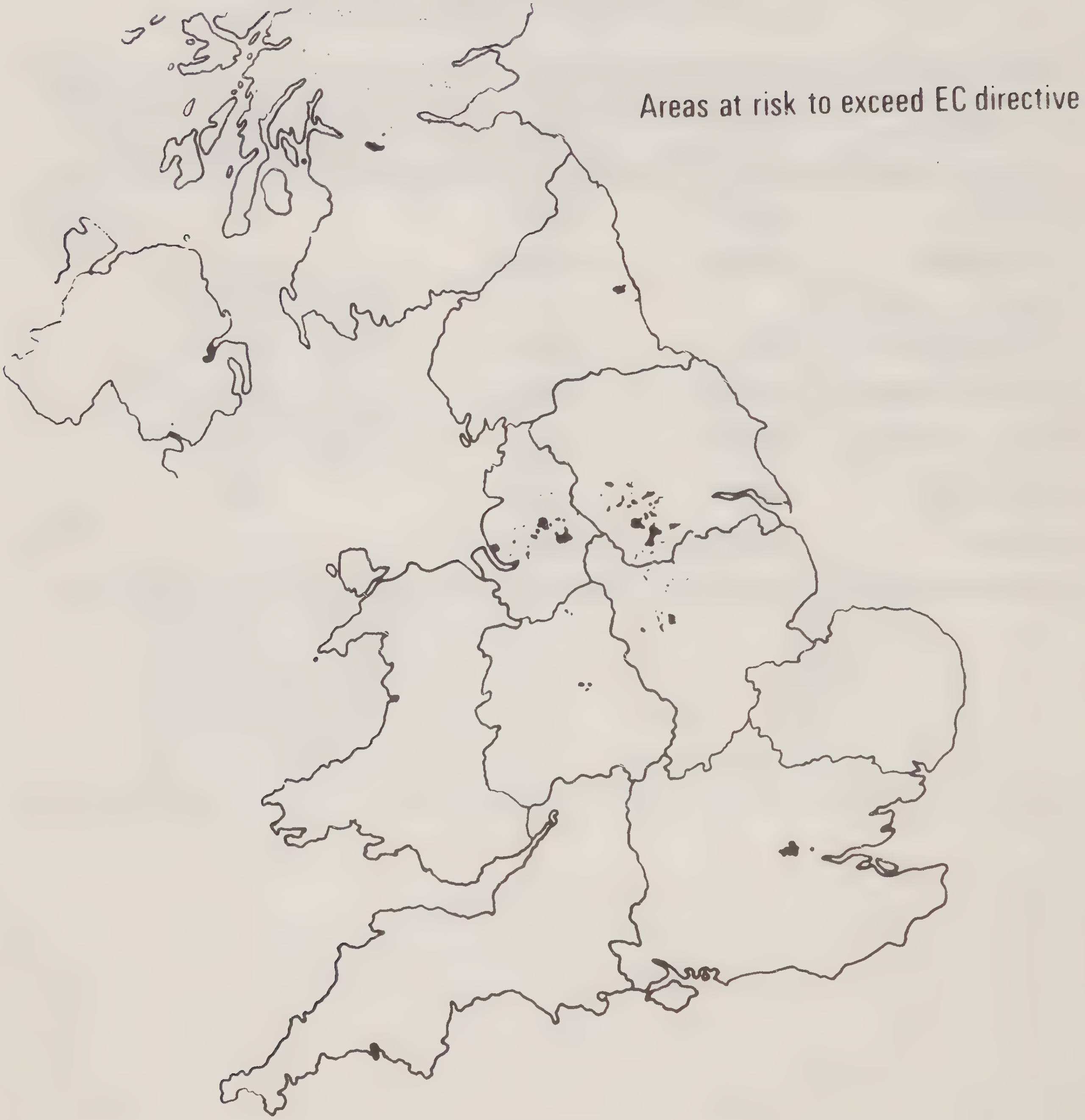


FIG.1 AREAS AT RISK OF BREACHING EC LIMIT VALUES: SMOKE AND SULPHUR DIOXIDE

(Published by DOE, 1981)

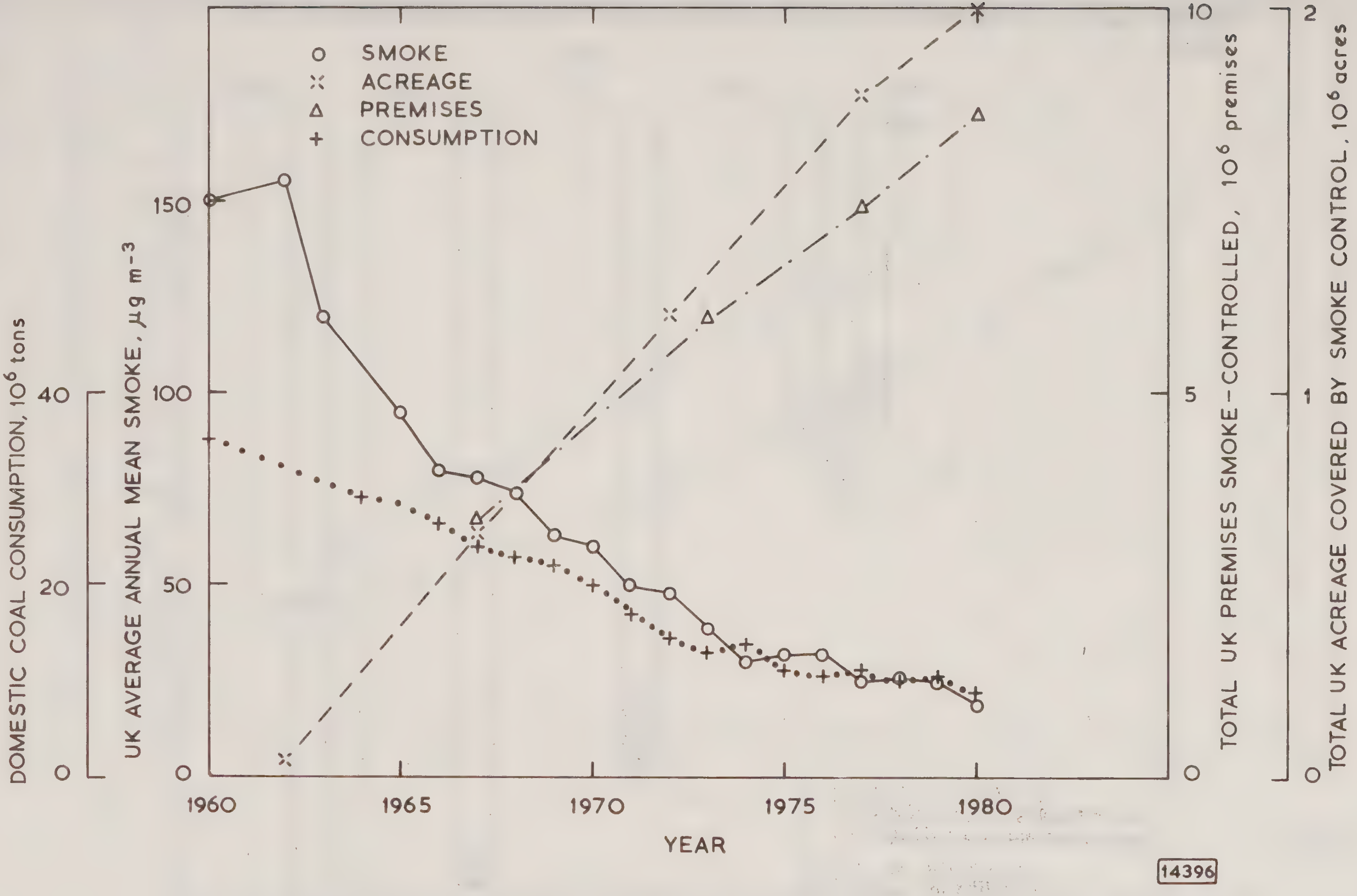


FIG. 2 UK SMOKE CONCENTRATIONS vs EXTENT OF SMOKE CONTROL, 1960-1980

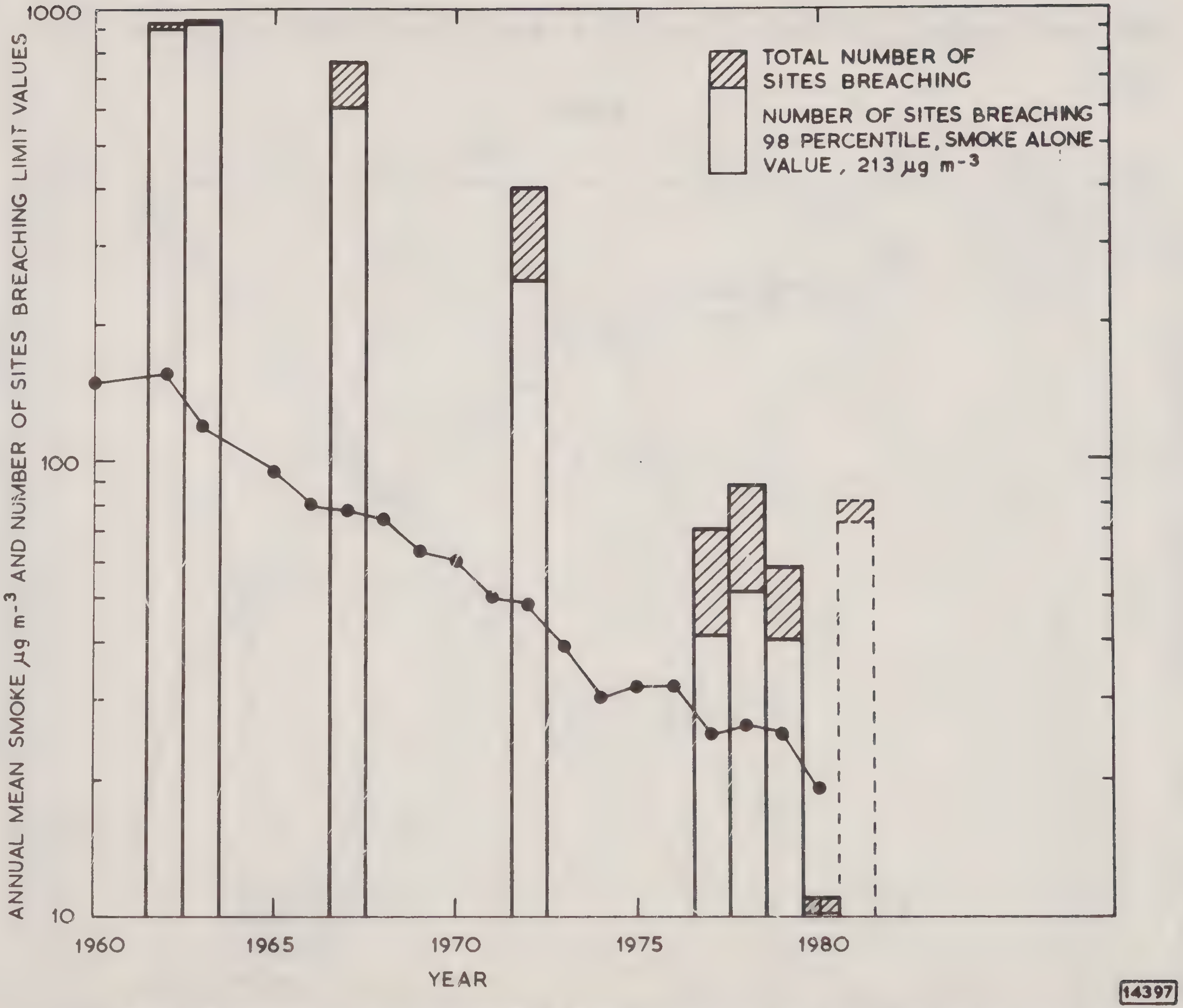


FIG.3 UK URBAN ANNUAL AVERAGE SMOKE CONCENTRATIONS AND BREACHES OF EC HPS DIRECTIVE

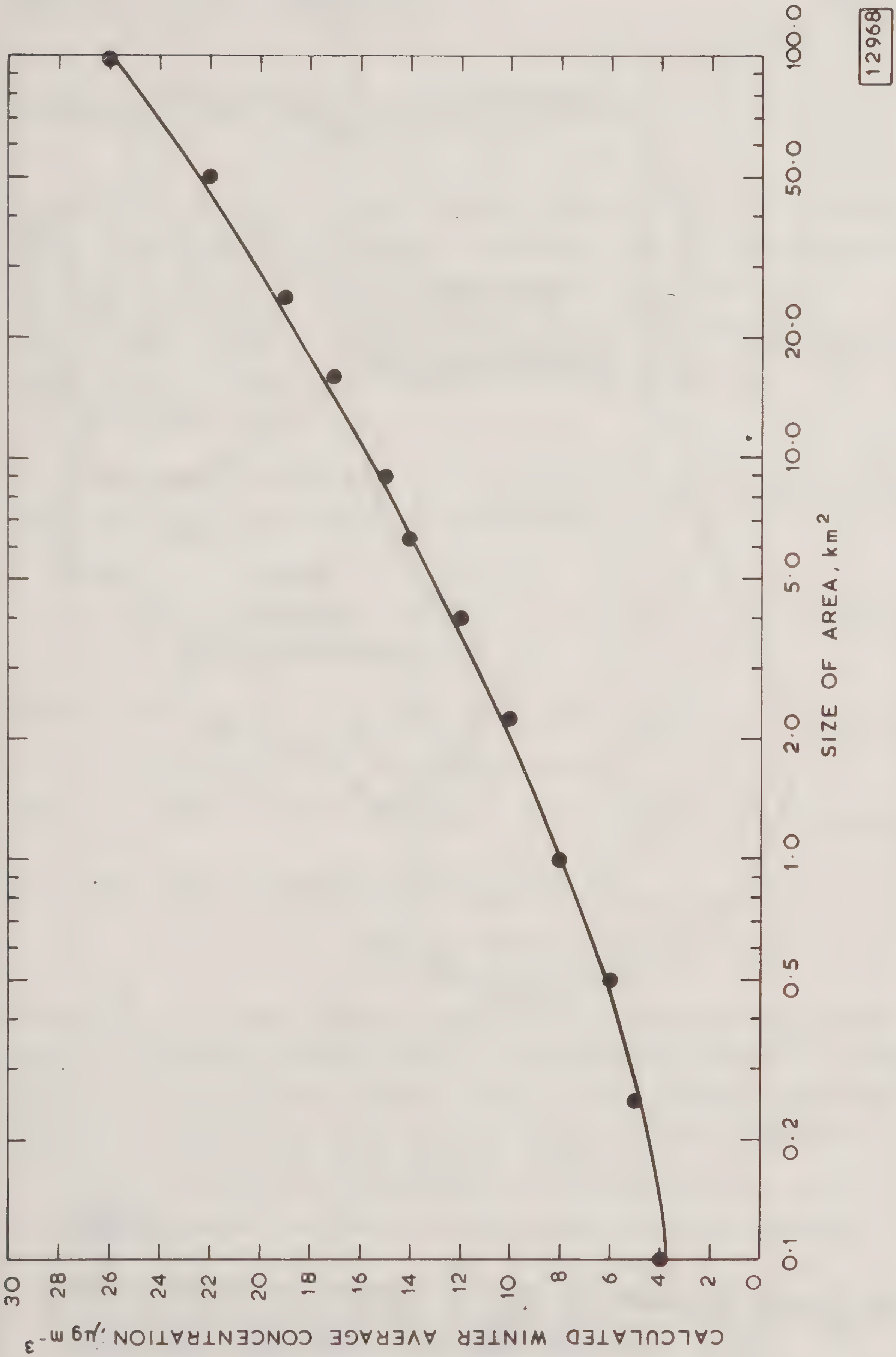


FIG.4 CALCULATED WINTER AVERAGE CONCENTRATION vs SIZE OF AREA FOR ANNUAL COAL CONSUMPTION RATE OF 1000 tonnes per km^2 (EXCLUDING BACKGROUND CONCENTRATION C_o)

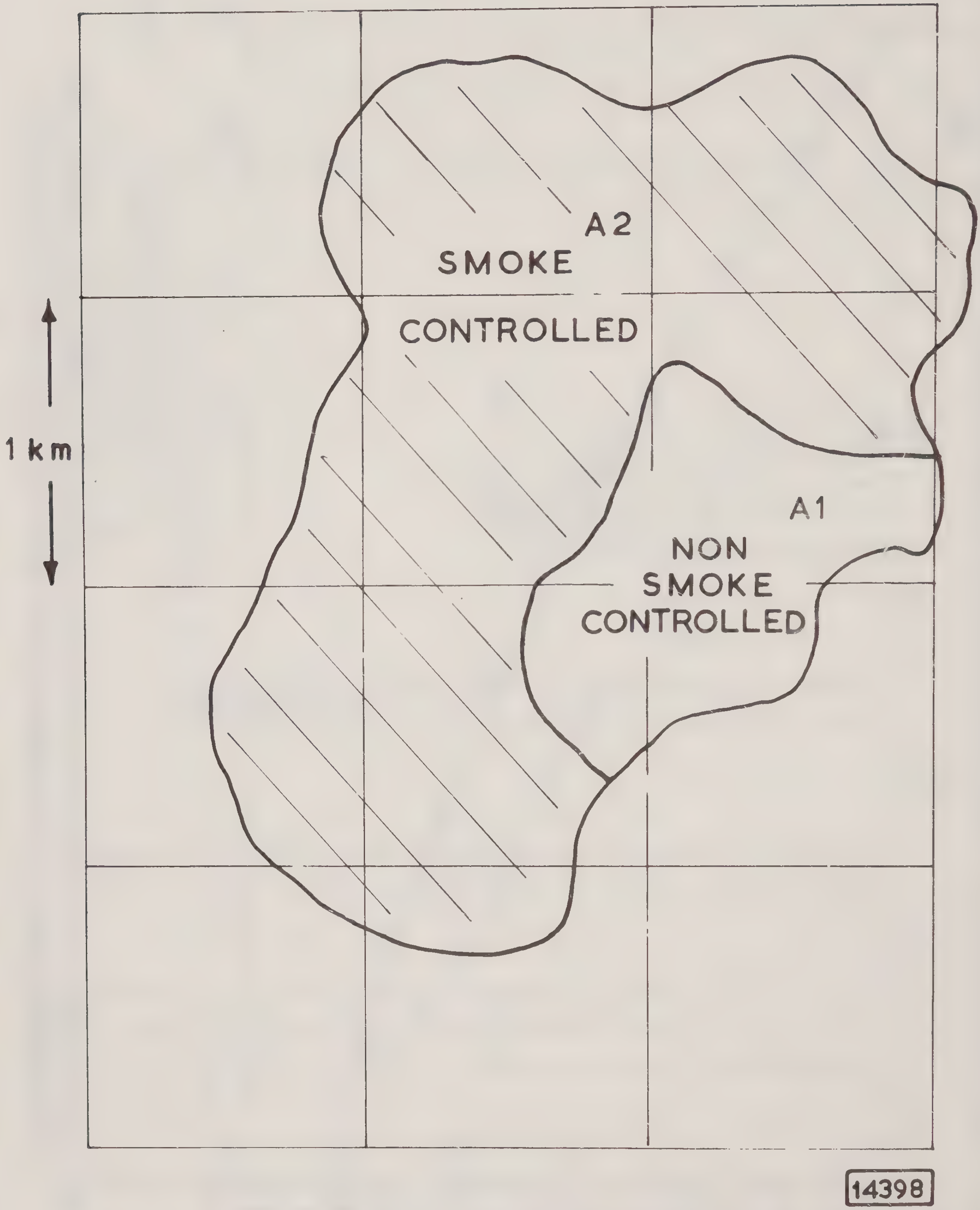


FIG. 5 AN EXAMPLE OF A DENSELY POPULATED AREA WITH EXTENDED SMOKE CONTROL

WARREN SPRING LABORATORY

APPENDIX A

BRIEF DESCRIPTION OF A "BOX" MODEL

1. In the simple "box" model approach it is assumed that the area of multiple emitters can be treated as a square and that the emissions from within the square are mixed uniformly up to a height, L(m), determined by the size of the square and atmospheric stability. Figure A1 shows the box model in diagrammatic form.

2. The concentration, C(µg m^{-3}), due to emissions from within the square is given by:

$$C = \frac{Q}{UaL} \qquad (1)$$

Where Q (µg s^{-1}) is the emission rate of the pollutant

U (m s^{-1}) is the wind speed

and a (m) is the length of the side of the square.

3. The "box" height, L, is given by

$$L = \sigma_{zo} + \sigma_{z}(a/2) \qquad (2)$$

Where σ_{zo} is the initial vertical spread of the pollution due to building entrainment, etc and σ_{zo} (a/2) is the additional vertical spread due to the normal atmospheric diffusion processes, computed for a travel distance of half the length of the square side.

4. For typical built-up areas and for long-period average concentrations L has been computed from

$$L = 25 + 0.247\ (1.6 - 0.12\ \log_{10}(^{a}/2).^{\,0.7266} \qquad (3)$$

(This assumes a roughness length of 0.5 m and neutral atmospheric stability)

5. The typical value of U adopted is 4.0 ms^{-1}.

6. If the distribution of emissions (or, for example, coal consumption) is not uniform then equation (1) can be applied to grid squares within grid squares if required. For example, consider an area, A_1, of dimensions 1.5 km x 1.5 km and with an emission rate Q_1 µg s^{-1}. Then $a_1 = 1500m$, $L_1 = 63m$ (from equation (3)) and $C_1 = 2.6.10^{-6}Q_1$, from equation (1). However, if 80% of the coal combustion, and therefore emission, is within the inner 0.5 km x 0.5 km area, A_2, then C_1 will be an underestimate of the value of C in this inner area. For this smaller area $a_2 = 500$ m and $L_2 = 43$ m.
The value of C for this inner area is given by

$$C = C_2 = \frac{0.8Q_1}{Ua_2L_2} + \text{contribution from remaining } 0.2Q_1 \text{ in the larger } A_1$$

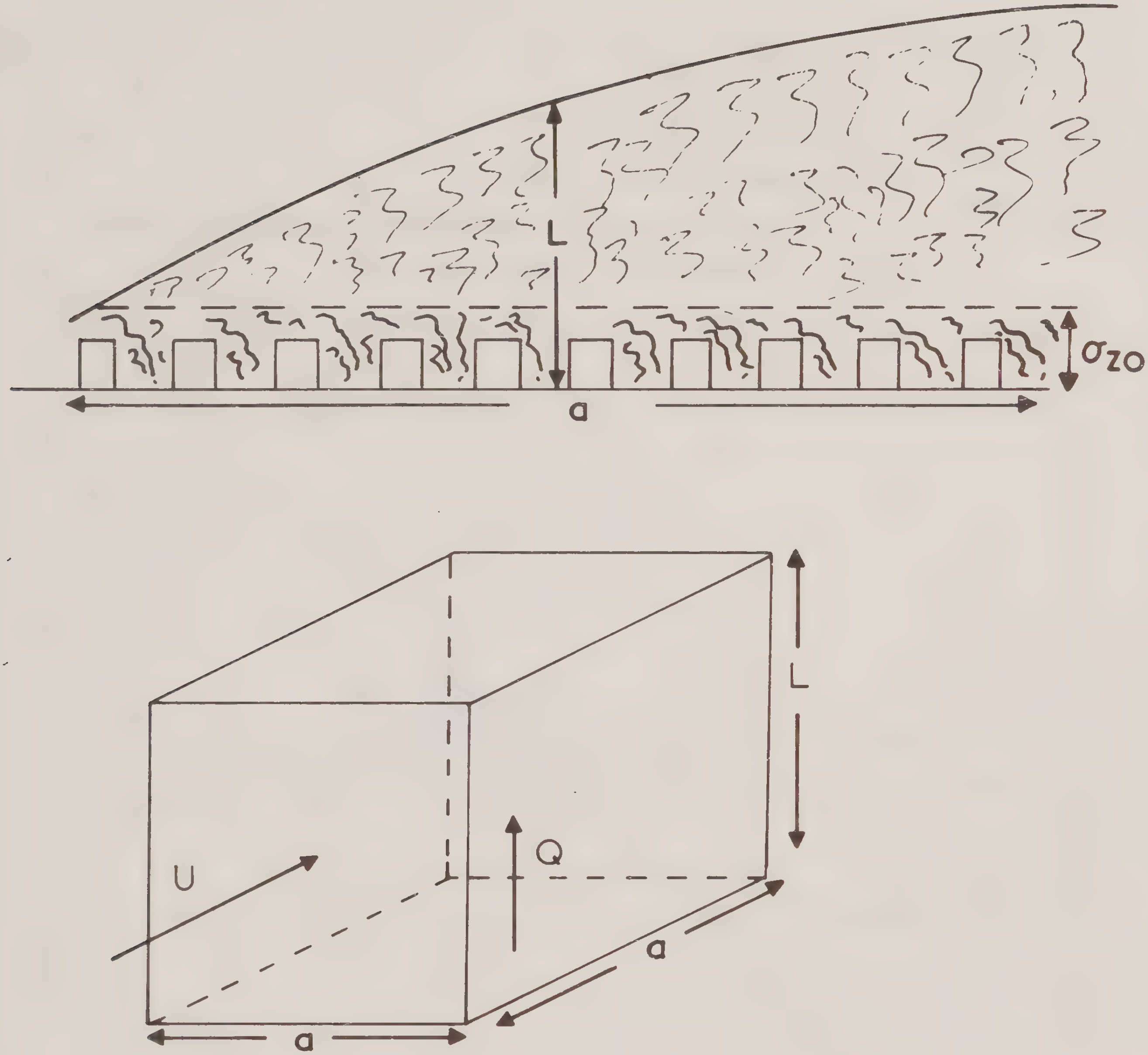
$$= \frac{0.8Q_1}{Ua_2L_2} + \frac{0.2Q_1}{Ua_1L_1}$$

$$= 9.8.10^{-6}\ Q_1,$$

a value which is almost 4 times the value of C_1.

7. Fig A2 shows comparisons between modelled and observed winter average smoke concentrations from two studies carried out by Warren Spring Laboratory.

8. It should be noted that the "box" model is not valid for estimating concentrations around individual sources or for sources with high chimneys.



1) BACKGROUND ENTERING BOX $= aLUC_o$

2) EMISSIONS $= Q$

3) POLLUTION LEAVING BOX $= aLUC$

$$C = \frac{Q}{aLU} + C_o \qquad = C_1 \div C_o$$

$\boxed{14395}$

FIG.A1 THE BOX MODEL

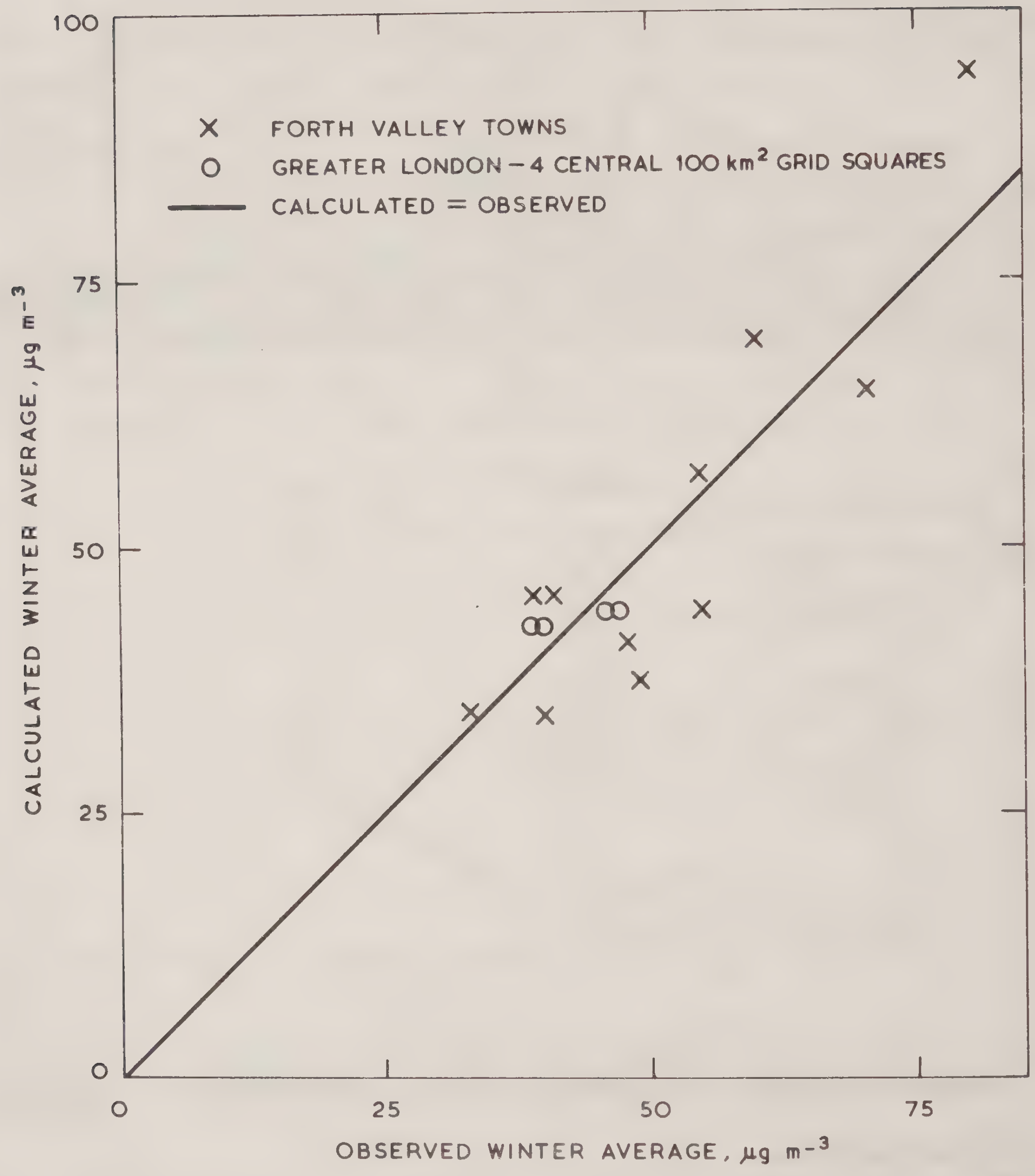


FIG. A2 COMPARISON BETWEEN CALCULATED (BOX MODEL) AND OBSERVED WINTER AVERAGES

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19 OCTOBER 1982
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NSCA SURVEYS
'COAL BURNING IN SMOKE CONTROL AREAS' 'ENFORCEMENT OF THE CLEAN AIR LEGISLATION'

By

Air Commodore J. Langston
Secretary General, National Society for Clean Air

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136 NORTH STREET
BRIGHTON BN1 1RG
ENGLAND

NSCA Survey
Use of Unauthorised Fuel (Bituminous Coal) in Smoke Control Areas - Winter 1981/82

SCOPE OF THE SURVEY

All of the 224 local authorities exercising smoke control in Great Britain and Northern Ireland were invited to complete the questionnaire at Annex A.

RESULTS

Of the 113 local authorities which responded:

19 (or 17%) considered the burning of bituminous coal in Smoke Control areas to be a sizeable or significant problem
whilst -
40 (or 35%) saw it as being a problem of lesser dimensions but, nevertheless, a cause for concern.

(Note: Unsurprisingly, the questionnaires were completed in a wide variety of styles: the above groupings reflect the subjective assessment of the Secretary General)

A more detailed breakdown of these results by DOE geographical regions is at Annex B.

A tabular summary of the nature and extent of the problem is at Annex C.

CONCLUSIONS

1. The illegal burning of raw coal in smoke control areas can quickly become widespread. For example, one Metropolitan Borough reported over 400 infractions in a single smoke control area, while another Metropolitan Borough and a London Borough reported 600 and 200 infractions respectively. In all 3 cases the remedy adopted was a publicity campaign backed with a very few

prosecutions.

2. Where infractions occur, in the first instance most local authorities issue general warnings. Most state their reluctance to prosecute - particularly OAPs and low income families.

3. Several local authorities consider that residents of long established smoke control areas are often unaware of Smoke Control Area fuel/smoke emission requirements.

4. Several local authorities state that they do not have the resources to monitor smoke control with consequential low priority given to its enforcement.

(NSCA suspects this situation could be general)

5. Offences by local merchants and traders under Section 9 of the Clean Air Act 1968 appear to be mainly a problem in Scotland.

6. In England the problem lies mainly in "corner shop" sales.

7. Illegal use of miners' concessionary coal appears to be mainly a problem in England.

Annex A

A. USE OF BITUMINOUS COAL IN SMOKE CONTROL AREAS

NAME OF AUTHORITY: ....

1. Sales from shops located inside Smoke Control Areas 1.9.81 to 28.2.82

	Known Number	Best Estimate
Shops selling bituminous coal only		
Shops selling solid smokeless fuel only		
Shops selling solid smokeless fuel and bituminous coal		
Bags of bituminous coal sold (10kg.)		
Bags of solid smokeless fuel sold (10kg.)		

2. Infractions of the Clean Air Acts, Winter 1981/82

Act	No. of Infractions	No. of warnings	No. of Prosecutions	Any other Action*
CLEAN AIR ACT, 1956 SEC. 11(2) SMOKE CONTROL AREAS				
CLEAN AIR ACT, 1968 SEC. 9 SALES OF UNAUTHORISED FUEL (BITUMINOUS COAL)				

* If you would like to expand on action taken by your authority to deal with infractions of the Clean Air Acts, or on the situation regarding use of bituminous coal in smoke control areas in your authority, please use the space below

....

....

....

....

....

....

....

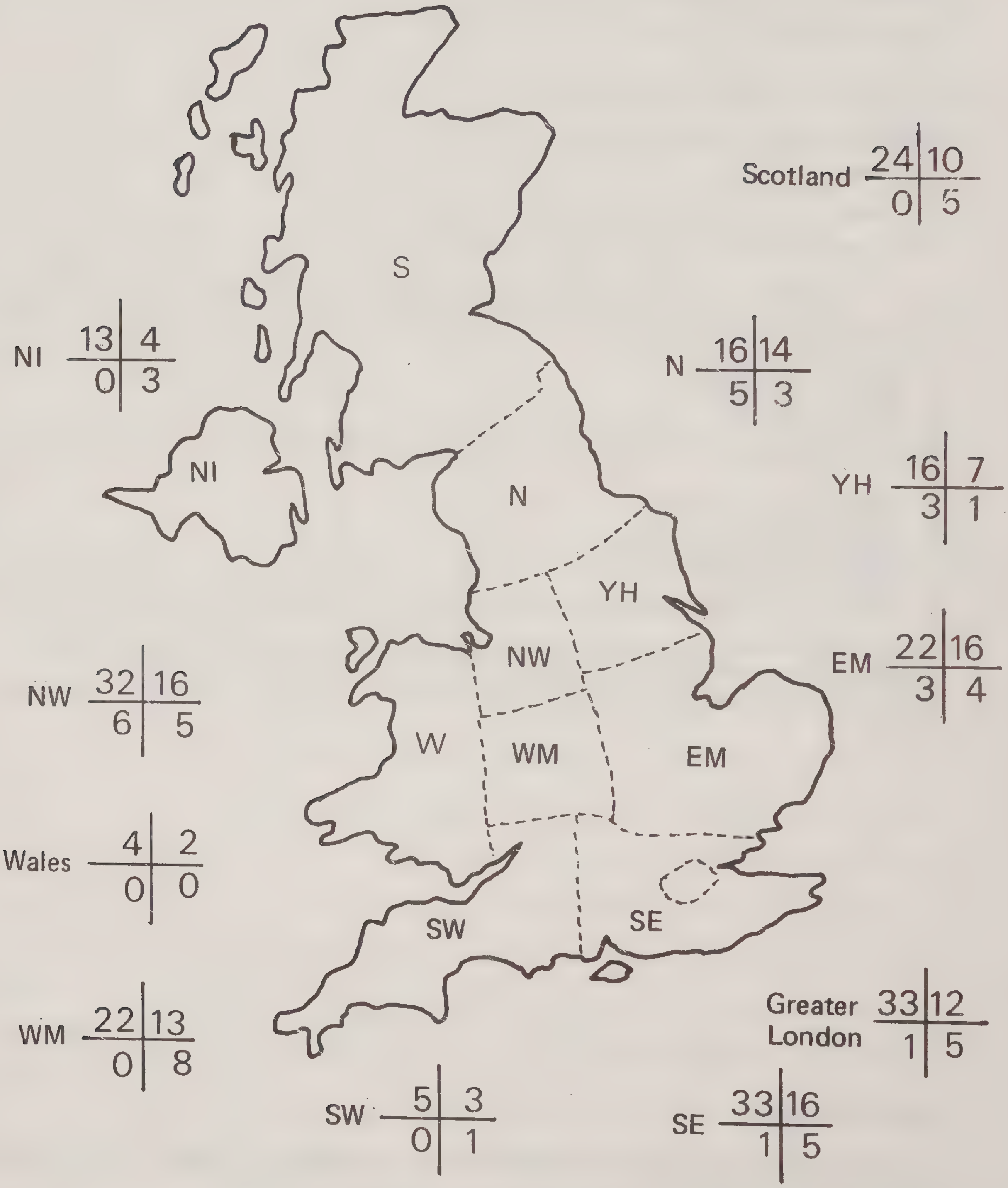
Name of Officer ....

PLEASE RETURN THIS FORM WHEN COMPLETED TO: THE SECRETARY GENERAL, THE NATIONAL SOCIETY FOR CLEAN AIR, 136 North Street, Brighton BN1 1RG

Annex B

KEY

No. of Authorities Excercising Smoke Control	No. Responding to Questionaire
No. Reporting a 'Significant' Problem	No. Reporting a Problem



Annex C

GENERAL SUMMARY

	NUMBER OF LOCAL AUTHORITIES BY REGIONS										
	SCOTLAND	N. IRELAND	NORTHERN	YORKSHIRE & HUMBERSIDE	NORTH WEST	W. MIDLANDS	E. MIDLANDS	GREATER LONDON	SOUTH EAST	SOUTH WEST	WALES
1. Reporting Infractions of Clean Air Act 1956 Section 11(2)	5	3	8	4	11	8	7	6	4	0	0
2. Regarding "Corner Shop" sales as:											
Major Problem*			1	1	2	1		1	1		
Minor Problem						1	2	1	2		
Suspected Problem					1		1	1			
3. Reporting Woodburning as a problem	1		1			1		3	1		
4. Reporting Misuse Miners' Concessionary Coal			1	1		1	3				
5. Reporting illegal trading in sea coal			2								
6. Reporting infractions of Clean Air Act 1968 Section 9 (by traders and merchants)	5			1	1						

* 7 Authorities make specific calls for amending legislation to close the loophole in the law re "corner shop" sales.

NSCA SURVEY

"Clean Air and Noise Legislation Enforcement 1980/81"
Numbers of Prosecutions, Range of Fines and Costs Awarded

Division & Penalty	Clean Air Act 1968 Sec. 1 Dark Smoke	Clean Air Act 1956 Sec. 1 Chimney Smoke	Clean Air Act 1956 Sec11(2) Smoke Control Areas	Clean Air Act 1968 Sec. 9 Unauthorised fuel sales	Control Poll. 1974 Sec. 58 Noise Nuisance	Control Poll. 1974 Sec. 62 Vehicle Chimes
NORTHERN	6		7		3	3
Fines	£50 - £200		£5 - £50		£0 - £50	£10 - £15
Costs	£0 - £25		£0 - £15		-	-
NORTH WEST	33	5	20	4	15	17
Fines	£0 - £300	£0 - £200	£5 - £30	£5 - £15	£0 - £150	£5 - £50
Costs	£0 - £45	£0 - £25	£0 - £20	£0 - £10	£0 - £60	£3 - £30
YORKS.	13		2		3	3
Fines	£20 - £200		£5 - £20		£50 - £150	£15 - £20
Costs	£0 - £32		£0 - £20		£15 - £50	£10 - £15
W. MIDS	16	7	2	4	16	10
Fines	£20 - £200	£10 - £150	£10 - £15	£0 - £30	£15 - £250	£0 - £30
Costs	£5 - £35	£0 - £15	£10 - £15	£10 - £20	£0 - £60	£0 - £30
E. MIDS	3	2	2		8	
Fines	£50	£70 - £100	£0 - £10		£0 - £50	
Costs	£0 - £20	£20	£0 - £20		£0 - £50	

Division & Penalty	Clean Air Act 1968 Sec. 1 Dark Smoke	Clean Air Act 1956 Sec. 1 Chimney Smoke	Clean Air Act 1956 Sec11(2) Smoke Control Areas	Clean Air Act 1968 Sec. 9 Unauthorised fuel sales	Control Poll. 1974 Sec. 58 Noise Nuisance	Control Poll. 1974 Sec. 62 Vehicle Chimes
S. WEST					7	
Fines					£0 - £400	
Costs					£0 - £166	
S. EAST	4				5	4
Fines	£0 - £400				£50 - £100	£10 - £30
Costs	£10 - £50				£10 - £40	£6 - £20
LONDON BORO'S	29			2	43+	2
Fines	£0 - £150			£50 - £100	£0 - £200	£25 - £50
Costs	£0 - £50			£2 - £30	£0 - £100	£10 - £15
SCOTLAND	7		1	11	2	21
Fines	£10 - £100		0	£0 - £50	£50	£5 - £100
Costs	£0 - £30		0	0	£0 - £10	£0 - £20
WALES						15
Fines						£5 - £30
Costs						£0 - £10
	Clean Air (NI) Order 1981 Article 4				Poll. Control & Local Govt. (NI) Order 1978. Noise	
N.I.	Only effective from 30.3.81.			No similar legislation exists	2	
Fines					£25 - £50	
Costs					£8	

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49th ANNUAL CONFERENCE
20 OCTOBER 1982
LLANDUDNO

PUBLIC EDUCATION IN NOISE

By

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Large numbers of people are adversely affected by noise. The Organisation for Economic Cooperation and Development (OECD) estimate that 100 million people (15% of total population) in its 24 member states are exposed to noise levels greater than 65dB(A) L_{eq} and some 430 million (50% of total) to levels greater than 55dB(A) L_{eq}. Relationships between noise levels and annoyance suggest that, as a result of these levels, at least 16 million people in the OECD countries will be highly annoyed by the noise climate to which they are exposed. In the UK alone the population exposed to levels greater than 65dB(A) L_{eq} is expected to rise from 11% (approx 6 million) in 1970 to 17-20% (9-11 million) by 2000. Additionally, noise may be dangerous to health and hearing. In the UK alone some 2.6 million workers in manufacturing industries (excluding mining, construction and agricultural activities) are subject to levels which are likely to lead to disability in hearing for a proportion of that population. These risks are extended into recreational activities such as attendance at discotheques and pop concerts and other high noise level sports such as rifle or pistol shooting.

As a result of its definition, noise, ie unwanted sound, may be compared with and treated as one of the many other forms of pollution which we currently experience in society. However, unlike most pollutants, the same phenomenon at the same level, or dose, may also have beneficial effects as it is clear that 'unwanted sound' is a matter which is personal to both the 'receiver' and the 'transmitter'. Hence the same sound may give pleasure or annoyance to different people at one and the same time. Moreover, the individuals' perception of pleasure or annoyance may be reversed for the same sound on different occasions. Herein lies some of the difficulty in improving the noise climate, in that we are all noise 'transmitters' at some time in our daily lives. This being so any overall strategy to control noise must comprise two elements. Firstly, physical measures to reduce noise emissions from equipment and appliances and, secondly, an educational programme designed to increase the awareness of individuals to perversities of noise.

In most countries which have a noise control policy the strategy is directed, principally, towards physical noise control measure. Such measures can often achieve appreciable reductions in the noise levels to which people are already exposed but the majority of such measures are expensive, passive treatments - such as barriers, enclosures, silencers etc. - where much depends on subsequent maintenance to retain the benefits initially achieved. Significant changes in noise level, either for good or bad, occur mainly through changes in technology and/or design; for example, the turbo fan jet engine, the electric car or the introduction of Concorde. Even so where levels are reduced by such developments it is often more by chance than by direct design. Designing for low noise emissions is often low on the priority list of the engineer compared with such criteria as performance, efficiency and economy. Such considerations are influenced by the prevailing social and economic climate; hence, they may be influenced by social pressures arising from an 'educated' public.

This paper will explore the ways in which educational programmes can contribute to public awareness of noise problems and possible improvements in the noise climate by examining the roles of Central and Local Government, Industry and Commerce, Education and the Professions. In particular, reference will be made to the influence of the EEC, quiet community programmes, noise labelling of products, noise in the home, recreational noise and education in schools.

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LLANDUDNO

NOISE ABATEMENT ZONES – CAN THEY BE MADE TO WORK?

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A. INTRODUCTION

1. Industrial and commercial expansion associated with technological advances since the Industrial Revolution has resulted in economic growth producing higher benefits to society. However, this largely uncontrolled growth has brought with it certain unfortunate and undesirable elements including pollution by noise, thus creating conflicts between industrial, commercial and domestic sectors. Absolute freedom from environmental deterioration is almost unobtainable if industry is to function economically, but a balance is required between the inevitability of pollution and the need to protect life and well being effectively.

2. In 1971 the report of the Noise Advisory Council: Neighbourhood Noise recommended that local authority control of neighbourhood noise should be reinforced by the application of more comprehensive measures within areas of special control. This concept received official recognition by the introduction of noise abatement zones in the Control of Pollution Act 1974.

3. Noise abatement zones are areas designated by local authorities under powers conferred on them by the Control of Pollution Act 1974 in which they may control noise from classified premises. A local authority may designate all or part of its area as a noise abatement zone, the purpose of which is the long-term control of noise from fixed premises in order to prevent further deterioration in existing levels of neighbourhood or community noise levels and to achieve reduction of those levels wherever possible.

B. NEED FOR CONTROL OF COMMUNITY NOISE

1. The Wilson Committee in "Noise - Final report of the Committee on the Problem of Noise 1963" defines noise as "a sound which is undesired by the recipient". Undesirability is a matter of subjective judgement having regard to individual tolerances, but nevertheless noise affects all activities and can create physical and mental problems.

2. Noise amounting to a nuisance can be controlled by the Control of Pollution Act 1974, sections 58 and 59 in conjunction with BS4142: "Method of rating Industrial Noise affecting mixed Residential and Industrial Areas" and it may be argued that those controls are sufficient to adequately counter most aspects of unsatisfactory levels of community noise. But these procedures relate to the existence of nuisance and do not take account of the need to prevent escalation of noise or to reduce wherever possible.

3. It is unrealistic to contemplate complete elimination of noise but there is a need for effective harmonisation and acceptance of corporate responsibilities between government, industry and commerce, and the domestic element if protection measures are to be practically applied for the majority benefit. Noise abatement zone procedures in principle provide a basis for co-operation in this respect.

C. CRITERIA FOR SUCCESS OF NOISE ABATEMENT ZONES

1. Every environmental decision involves a balance between benefits and hazards and one must decide whether majority benefits resulting from action under Part III of the Control of Pollution Act 1974 at reasonable expense and practicality will produce the environmental harmony in community noise that is intended.

2. The criteria will therefore be determined by the reconciliation of the objectives of industry and domestic life with improved environmental quality. It will be met if the benefit accrued shows a surplus or at least equals the resource necessary to control community noise effectively by noise abatement zones.

D. ALTERNATIVES

1. Decisions to apply noise abatement zones to control community noise rely on the presumption that such controls are the most realistic in the circumstances.

But there are alternatives which may be of benefit to the recipient of undesirable community noise depending on the prevailing conditions.

2. Perhaps the first reaction to disturbing or damaging noise levels is to accept it as a necessary adjunct to industrial life. This implies grudging tolerance of an undesirable environment and will probably result in initial annoyance factors becoming increasingly damaging as levels escalate under uncontrolled conditions. In this instance, controlled cost incurred by industry or commerce will be virtually nil, at least from an environmental point, but the social cost to be borne by recipients could be considerable.

3. It may be possible to move noise sources to less sensitive areas but costs are involved, including considerations associated with the economic operation and convenience of relocated business. In any event, such proposals may simply result in a transference of problem and the introduction of higher noise levels at the secondary location, which may not be particularly sensitive initially but may become so in the future.

4. The insulation of noise sources against impingement on the community levels is a realistic approach to noise abatement. There are costs involved and which may be expensive to be borne by the polluter, but if these costs are commensurate with providing a more comfortable environment for society, or the individual, then it might be regarded as advantageous to carry out this form of control. Conversely, regulations made under the Land Compensation Act 1973 have provided for protection to be made available to domestic premises in receipt of high noise levels emanating from road traffic, as a result of new or reconstructed highways. This can be effective but is expensive and may not be cost-effective, depending on the viewpoint. But the principle involved in noise insulation could equally apply to noise impingement from industry and, presumably, the polluter would be required to pay either in total or in part.

5. It can be argued that a total shut down of the noise producing plant is the most realistic method of control, purely from the environmental point of view. But the social and economic considerations in this connection would far outweigh any such notion. A total shut down of plant would result in unemployment and a depressed economic situation. Therefore, such a form of control becomes totally unrealistic in any free economic society.

6. Section 58 of Control of Pollution Act 1974 allows for the control of noise that can be properly regarded as a nuisance. These controls are effective but can only be regarded as isolated control in so far as they relate to the reaction on a nuisance basis between a noise source and a recipient. While such controls have contributing factors to overall community noise levels, to provide effectively for surveillance by this method would be extremely time-consuming and would not, necessarily, bring about the desired effect. Reference to BS4142 advises action to be taken only in the event of nuisance, while procedures under noise abatement zones provide for reductions in levels whether or not nuisance exists, which is an extremely significant power available to local authorities.

7. Tolerance of the individual to noise dosage differs according to many factors, including age, occupation, attitudes etc. Therefore, it is impracticable to attempt target ratings on community noise issues which will, effectively, satisfy all recipients. Sound pressure levels exceeding 140 dB involve physical damage, whilst discomfort may be experienced at sound pressure levels of over 100 dB. Target or threshold limits designed to reduce exposure to these levels are appropriate but at the much lower levels concerning community noise levels do not lend themselves to meaningful control. Day time noise levels of 50 dB(A) Leq or less appear to cause little hazard but a community noise target of this figure is unrealistic and unlikely to be achieved in all but the most rural areas.

8. Local authorities can ensure that existing ambient

noise levels are held down wherever possible when planning applications are being considered. If this is not possible it is not normally justifiable to allow development which will result in corrected noise levels of 75 dB(A) by day or 65 dB(A) by night. However, planning controls can only relate to new proposals, and errors may occur in predictions of the future noise emission from these developments.

9. Alternatives mentioned do have possibilities and, in specific circumstances, may offer more appropriate protection to society against undesirable levels of community noise. However, the conclusion may be that noise abatement zones are more realistic under normal conditions met in combatting excessive noise levels within the environment as a whole.

E. PROBLEMS

1. There are of course many problems associated with the implementation of noise abatement zones and these can be divided into three main headings, that is, Concept, Decision; and Operation.

Concept

2. The discretionary powers available to control community noise by noise abatement zones must be activated by pressures exerted on local authorities in response to specific needs, and problems arise in determining whether the concept of control by this method is appropriate or desirable. If noise amounting to a nuisance exists from particular sources the use of noise abatement zone procedures may not be necessary and alternative powers under the Act could be implemented. A purpose of noise abatement zones is to prevent levels escalating to annoying and subsequently damaging proportions, but it is the local authority's task to decide to apply one control in preference to another based on the relevant circumstances in each case. It is common that new controls are resisted but opposition often disappears and approvals received after time and

experience produce tangible benefits. Nevertheless, if negative philosophies prevail and apathy, lack of enthusiasm, or over-caution exists the concept will fail.

Decision

3. Decisions of local authorities in times of severe economic constraint, particularly associated with relatively new and little used powers suggesting expansion of services, are usually received with some caution. Similarly, those responsible for classified premises within proposed zones may regard new controls as unnecessary, restricting and financially unacceptable if expenditure or reorganisation of plant and procedures are required for compliance with an order.

4. Therefore it may be beneficial initially to take the decision to designate an area as a pilot noise abatement zone and to design a time-scaled programme and partly or totally control noise sensitive situations subject to the benefits and experience gained from that pilot scheme.

5. The decision must however relate to the available resource in terms of manpower and finance. If noise abatement zones are to succeed under adverse economic conditions they must be implemented within the existing establishment and financial framework of the local authority. In practice this will probably mean the redirection of competent staff on a part-time basis to carry out the procedures involved. The manpower level depends largely upon the projected programme and the time-scale under consideration. But limited achievement can be made in pilot schemes or the early stages of a programme by two officers with the necessary experience and technical expertise.

6. Costs involved in the implementation of noise abatement zones, excluding staff contributions, largely involve equipment and administrative expenses. If works are initially to be carried out within the existing staffing framework, then extra costs, other than perhaps overtime payments, should not be incurred, and office

administration costs, including postage, duplicating etc. should be minimal. The most important aspect of noise abatement zones in relation to local authority costs is the cost of measuring equipment. Work on noise abatement zones revolves around the accuracy of sound level readings and these must be obtained by equipment complying with the requirements of BS4197:1967. These systems can be expensive, although many local authorities will possess the equipment for use on noise control in other directions and it is, therefore, not required expressly for noise abatement zone work.

7. Expense may be incurred by the owners and occupiers of classified premises in reducing noise to an acceptable level. It is difficult to estimate these costs since noise reduction works may range from merely closing doors or windows, to insulation works of a complex nature.

8. A lack of resource in manpower and finance is of primary importance in reaching the decision but should not be used as simple excuse for non-implementation of noise abatement zones procedure if it is both necessary and expedient to impose control of community noise by this method. If a need is proved then the available resource, however limited, can normally be redirected and should have some effect.

Operation

9. Operational advice is given in Circular 2/76: Control of Pollution Act 1974, Implementation of Part III - Noise, and is intended to give guidance to local authorities in implementing the relevant sections of the Act, although it is perhaps fair to say that potentially difficult situations are not necessarily covered by the advice.

10. The area to be designated as a noise abatement zone needs to be determined with some care. The proposal should normally cover an area with a predominance and high density of residential properties in close proximity to classes of premises involving noisy processes. It

should also allow for relatively simple determination of noise control boundaries.

11. To set the zone boundary itself requires careful consideration and this should not be rigid but should vary around classified premises to take account of the noise escape which may result outside the zone boundary.

12. Classified premises are those premises to which noise abatement zones will apply, bearing in mind the types of processes or activity involved and the benefits afforded by such controls. Classification rests with the local authority with regard to local circumstances and the need to control specific premises, either existing at the time of the making of an order, or to be included in future development plans. Normally domestic premises and short-term noise sources will be deliberately excluded from the classification of premises since control is more appropriately implemented by other provisions of the Act. In any event the numbers of domestic premises will be too great for effective registration and monitoring of noise levels and domestic noise problems is usually of limited duration. However, problems can arise in this connection since conflicts can be created by those persons responsible for compliance with an order and noisy domestic activities outside controls of this type.

13. The local authority has the discretion to determine the classes of premises to which noise abatement zones procedures will apply, including premises which may be represented in the future. It can be argued that it is only necessary to register the levels emanating from those premises likely to create excessive noise, and therefore to exclude most shops, garden centres and types of businesss. Consideration should also be given to the status accorded to sportsgrounds including speedway tracks where the noise producing activity is once or twice weekly in seasonal periods. But, if uniformity is to exist and operations within the zone are to be treated equally, it may be advantageous to include all premises other than domestic premises or appurtenances associated

with domestic premises. Premises having a proportional domestic use, for example, the house and shop situation, can be treated according to the degree of the use.

14. The measurements or calculations obtained are recorded in a noise level register kept by the local authority, and these form the basis of control of classified premises in the noise abatement zones. If problems in relation to the registered noise levels are to be minimised it is advantageous to obtain measurements and discuss the fairness and accuracy of the results with representatives of the classified premises before a record is made in the register, thus fostering a good relationship between all concerned which is the keynote of any operation of this type.

15. If the noise level emanating from classified premises is not acceptable and a reduction in that level is practicable at reasonable cost and to the public benefit, then the local authority may serve a "noise reduction notice" requiring steps to be taken to reduce the level of noise emanating from the premises and to prevent any subsequent increase in the reduced level. However, if good relationships are to be maintained and problems averted in the initial stages it may be prudent to attempt to reduce an unacceptable noise level prior to registration and resort to notice procedures only where occupiers prove to be uncooperative after the zone is effective.

16. If the registered levels are to be effectively monitored the measurements must be accurately made, and the number and positions of measurement points will dictate the degree of control. Therefore, it is an advantage to be able to correlate a point on a map with a specific point or marker on site, such as a gully, lamp standard etc. Measurement conditions must be capable of being faithfully reproduced otherwise monitoring becomes ineffective and a complete waste of time!

17. In some circumstances it will be impossible to measure noise levels where the noise control boundar

would normally occur, such as when a classified premise has a common wall with another classified premise. In such cases calculation may be used to determine a level, although it may be possible to ask for a shut-down of one classified premise whilst readings are taken at the other. However, management normally find it impossible, or are reluctant to shut down to enable readings to be taken. Problems do exist in determining specific noise emission when dominant extraneous noise is evident.

18. Subjective analysis of the type of noise emitted from the premises must be the first objective, otherwise problems will arise in the future. Only in this way can determination on the number of measurement points and the period of interest be made. If a fairly even distribution is apparent, then a representative sample can be obtained over a relatively short period. A period of interest does not necessarily need to extend to lengthy proportions but if readings are to be truly representative, then it becomes necessary to confirm with management that the working operation at the time of measurement is a genuine example of the usual type of noise emanating from the premises. Therefore discussion must be had with the management in an effort to obtain their cooperation so that this can be done. It is of little use measuring levels which may have omitted the most noisy process in the premises, which might at the time of sampling have been closed down either for repair or some other factor. Similarly care must be taken to see that windows and doors are in their normal positions and in this respect it is probably better to obtain noise levels in summer when windows and doors are open rather than in winter when they are normally closed.

19. On taking noise levels regard must be had to weather conditions. Adverse conditions of high winds, snow, rain, or fog present measurement problems and should be avoided, as should any extraneous noise which is not representative of the period of interest.

20. The implementation of noise abatement zones procedures must be kept as simple and uncomplicated as

possible if it is to succeed. The primary objective is to enable registered levels to be fair and representative and be perfectly capable of being reproduced at specific monitoring points in order to ensure that noise levels have not increased.

F. BENEFITS

1. The major benefits of control by means of noise abatement zones should be the preservation of facilities for quiet enjoyment of leisure time, satisfactory working conditions, and protection against stress and other health factors caused by escalating levels of community noise.

2. However, the benefits of improved noise climates should not be obtained at the disadvantage of one sector or another. It can be argued that benefit should be sought at whatever cost, financially or socially, based on the premise that health and comfort of the individual is of supreme importance and has precedent over all other considerations. Alternatively it can be similarly argued that since industry and economic generation is the root of society the more unacceptable by-products have to be tolerated in the pursuit of materialism. Therefore it is the balance that is important, and it becomes necessary to decide whether or not to stabilise or reduce prevailing community noise levels at reasonable control cost, or to accept the inevitable increase and resultant damaging elements in order to save on control costs.

3. Noise abatement zone procedures recognise the need for immediate curbs on escalation of community noise levels, and provide for planned reductions over a period where necessary at a reasonable expense and practicality.

4. Cost benefit analysis can be used as a means of determining the effectiveness of specific methods of control. The cost of control will be borne by both the local authority, in the form of manpower and equipment costs, and those classified premises that may be required

to incur insulation or other avoidance costs including relocation expenses connected with noisy processes.

5. However, these costs must relate to the degree of improvement obtained, that is, the benefit. A balance must be achieved between the potentially damaging elements such as loss of output, illness, relocation expenses, property values and other disruptions, and costs involved in noise reduction. The local authority must remain impartial and not unduly influenced by either sector.

6. Benefit can be obtained by the application of noise abatement zone procedures in precincts, new developments, general improvement areas etc. where the control of community noise levels can form part of the overall environmental improvement of the area.

7. Control of community noise by noise abatement zones can produce benefit at minimum cost to the local authority; provide for phased improvement by industry and commerce; and can give immediate protection to the population.

G. NOISE ABATEMENT ZONES - CAN THEY BE MADE TO WORK?

1. Noise abatement zones can be made to work, but their effectiveness depends upon a number of factors, having decided that it is appropriate to control community noise levels by this method.

2. It is unlikely that the public can itself judge comparison of noise abatement procedures against other possible control methods since it will not possess the necessary information and expertise to determine the issue, therefore the direction must come from the local authority. But it then becomes advisable to explain the procedures properly to the domestic sector, and to those responsible for classified premises. Every occupier of premises which will become classified should be interviewed if possible to discuss the implication of the local authority's proposal and its effect. Informal

discussion with those concerned is vital if a zone is to be successful.

3. Operational problems are created by noise sources outside the orbit of control. Noise from the domestic sector and traffic are excluded from the provisions of an order but can give rise to complaint and if not dealt with can seriously detract from the status of a noise abatement zone. One of the biggest problems in the noise abatement zone work is adequately to convince, and to be able to demonstrate to all concerned, that noise levels are initially static and may in fact reduce over a period in the future. If classified premises are to be controlled, probably at some cost, then the attitudes are obvious towards noisy equipment being operated by the domestic sector and noisy road traffic. If control through noise nuisance procedures and Motor Vehicles (Construction and Use) Regulations 1978 are inappropriate then the problem may be overcome to some extent by the implementation of a "quiet zone" in the area of the noise abatement zone. The Borough Council at Darlington agreed to accept an invitation of the Noise Advisory Council to participate in an experiment to see whether by everyone's combined efforts it was possible to reduce irritating and unnecessary noise in the Borough. A similar project within the boundary of a noise abatement zone may be successful by including the domestic element etc. within the spirit of a zone. However, the project would have no force of law and would rely entirely on cooperation and publicity. The content of a project would include the issue of leaflets to householders requesting considerate behaviour in relation to shouting in the streets, car doors slamming, continued playing of radios and other irritating noise sources; requests to motorists to check maintenance routines so that worn-out exhaust systems are replaced, engines are properly tuned and bodywork rattles eliminated; and publicity throughout the area describing the objectives of the zone and the offer of advice wherever necessary. Problems relating to these matters are very real and can affect the success of a noise abatement zone. Schemes to include voluntary reduction of noise from the domestic sector and road

traffic to a degree makes considerable sense, but a programme of continuing publicity is needed to preserve interest and impetus and this can be a problem.

4. The technical considerations can create difficulties and may lead to unworkable conditions if allowed to do so, but procedures should be kept as simple and as uncomplicated as possible. Provided that the registered levels can be satisfactorily checked and conditions be realistically reproduced, there is no reason why simple but effective controls cannot be applied.

5. The impact of noise abatement zone controls on a particular area must be considered when determining whether procedures have been effective. If the impact is a significant reduction in noise levels then an achievement will have been made, but if the achievement results in unrealistic constraints on industry beyond the bounds of practicality then the impact is not the right one. In such circumstances the zone will not work and status of noise abatement zones will reduce.

6. The relatively low input costs to the local authority in noise abatement zones is an advantage and can assist in making zones work, but the benefits produced socially by way of increased facilities for a quiet working and leisure environment must not be brought about by ill-founded control on industry which allows for little expansion. Such controls will not work. Noise abatement zones should allow for phased control which gives flexibility for industry in forward planning of its noise control and will work provided industry and the local authority genuinely cooperate in the exercise.

7. If noise abatement zones are to work properly into the future it becomes necessary to maintain interest. To maintain interest is a difficult matter and the local authority must not default on its monitoring responsibilities. The registered noise levels must not be forgotten, but should be checked from time to time. It is not suggested that regular, time consuming monitoring takes place, but rather that sample premises are checked or complaint investigated.

8. Noise abatement zones can be made to work provided there is commitment and enthusiasm on the part of the local authority to carry out the powers to the best of its ability. If apathy exists and problems are magnified then schemes are unlikely to be effective and may result in adverse comment directed at the local authority.

H. CONCLUSION

1. Noise abatement zones are relatively new and little used powers available to control community noise. The procedures do not rely on action based on nuisance, but provide for the limiting of existing levels and reduction wherever possible. If the need is demonstrated then it is up to the local authority to guide the requirement and to carry out controls which will show benefit to the community. Whilst there are defects in the procedures it may be felt that noise abatement zones can be made to work and produce significant effect on community noise levels. The integrity and credibility of the local authority depends upon the effective carrying out of its duties for the benefit of the community and if the control of community noise levels can be maximised at minimal cost, then it will be in good standing.

The opinions expressed in this paper are entirely my own and do not reflect the views and policies of the Metropolitan Borough of Calderdale or the Environmental Health Department.

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THE CONTROL OF NOISE BY PLANNING

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> "Our concern is not that pollution is not always given top priority: it is that it is often dealt with inadequately, and sometimes forgotten altogether, in the planning process"
>
> Royal Commission on Environmental Pollution.

Although written in the context of air pollution control, the above quotation from the Royal Commission(1) has been held to be equally relevant in the control of noise by the planning process. Much more attention is being paid to the noise potential of new development (perhaps partly as a result of such criticism) and the planning procedures are being increasingly used to prevent or reduce the impact of noise on surrounding noise sensitive areas or to restrict sensitive developments in locations of undesirably high noise level.

Unlike atmospheric pollution which is more difficult to control in this way, being dealt with by at least two enforcement agencies with often conflicting views and having problems associated with accurate and meaningful measurements, noise is widely recognised as being amenable to control by the powers contained in the planning legislation. As a consequence, much formal and authoritative advice has been available for some time to guide local planning authorities on what matters may be considered and how controls may be best effected.

For certain economic and political reasons, planning authorities are now however looking closely at the way in which adverse decisions or conditions attached to planning consents may affect economic processes, or cause unacceptable delays whilst the perceived needs for such controls are subjected to additional discussion. Criticism has also been levelled at the Environmental Health Departments for allegedly seeking to duplicate, by the use of the Planning Acts, powers available under alternative legislation which should more properly be used to achieve the objective of pollution control(2). It is not the intention of this paper to seek to promote unfair, improper or inappropriate application of planning controls but to attempt to rectify some misconceptions about the objectives of, and the constraints which surround, noise control by planning procedures.

It is also the author's objective to provoke a forum for discussion on the current vogue which appears to see planning as an essentially permissive process and which looks upon any attempt to restrict or regulate as being unnecessarily obstructive and economically undesirable. Such attitudes are typified by selective quotation from recent Government circulars and statements and tend towards demands for a reduction in restrictions upon development. What should be demanded is not less, not more, but better control. It must be remembered that what may appear to be economically or politically desirable in the short term may result in the production of long term problems for many years after the expedient decision has been made.

Before moving on to discuss how noise may best be controlled by the use of the various planning powers, it is reasonable to consider first the powers available to local authorities to deal with noise by alternative procedures. For the purposes of this paper, comment is restricted to 'fixed' developments such as new factories, commercial developments, new housing or other sensitive developments; thus, road, rail or air traffic sources will not be considered.

THE ALTERNATIVE TO NOISE CONTROL BY PLANNING

The alternative (apart from deliberate failure to recognise and deal with subsequent problems) would be to use the powers contained in Part III of the Control of Pollution Act(3). Section 58 contains both anticipatory and post factum powers to require noise which amounts, or will amount, to a nuisance to be reduced or prevented. There are several reasons why use of these powers may be inappropriate or impossible. It is common for planning authorities to speak of 'amenity' and it is clear that decisions made to preserve amenity, or to limit disamenity, enforced by planning conditions or refusal, can be held to be valid in planning law.

The Control of Pollution Act refers however to 'nuisance', an entirely different concept with its own body of case law which one must turn to for definition. Nuisance is a term which lacks the advantage of precise definition but which is in general taken to mean an unlawful interference with rights over land. Such interference must be substantial, and must be related in general terms to the likely response of the average man in the street, who would be expected to find the particular noise 'unacceptable', to allow action for nuisance. Without entering into a semantic argument, it is a matter of simple observation that there is a difference between that which is acceptable and that which is desirable. The limitation of emitted noise levels to preserve amenity should be taken as tending towards the achievement of desirable environmental standards rather than the avoidance of nuisance by seeking only to obtain a situation which does not prove unacceptable. For this reason it is common to find that noise conditions attached to planning consents are directed towards ensuring that pre-existing background levels are not increased to a degree which would be held to cause disamenity or even nuisance. Indeed, a condition which merely seeks to avoid the creation of nuisance could be held to be ultra vires, as the matters which would thus be controlled are themselves the subject of specific legislation i.e. Section 58.

Any action taken under Section 58 against persons operating a trade or business is subject to a subsequent potential defence of 'best practicable means'. As tests to be applied relate to the cost of a remedy, and to the state of technology at the time, it is evident that if a remedy cannot be found, or if found would be too expensive to implement, continuation of the resultant nuisance would be permitted. Such a defence (notionally at least) does not exist in respect of contravention of a planning condition: a good argument for control by that means.

Disadvantages of nuisance action may be summarised thus:-

1. The degree of disturbance needs to be 'substantial'.
2. The definition of nuisance is imprecise and variable

according to circumstances.
3. In general, control is available only over fixed sources of noise.
4. A 'best practicable means' defence may be applicable.
5. 'Acceptable' levels of noise are not necessarily synonymous with 'desirable' levels.
6. Post-operation remedies are invariably more costly than preventative measures taken at design stage.

It is appropriate here to point out that the adoption of a policy of conditioning planning consents to deal with noise will in no way diminish the overall workload of the local authority in general and of the Environmental Health Department in particular. In the short term, the amount of predevelopment survey and data gathering will be extensive and post-operative monitoring may be very demanding of resources. It is not possible to quantify the long-term effects either, but in the City of Manchester, complaints about noise from industrial and commercial sources have decreased over the past few years, paralleling the increased activity in the planning aspect. It may be a fortuitous coincidence, and only time will tell if the inference thus drawn was correct.

THE USE OF PLANNING CONDITIONS TO CONTROL NOISE

Good guidance is offered in Circular 5/68(4) on the tests to be applied to proposed planning conditions to determine their acceptability in planning law. These are summarised thus:-

Is it
(a) necessary?
(b) relevant to planning?
(c) relevant to the development to be permitted?
(d) enforceable?
(e) precise?
(f) reasonable?

Each question is carefully explained and examples are given to aid in the determination of the answer. Although of general rather than specific application, it is clear from the content that the then Minister of Housing and Local Government expected that noise from new development should be the subject of control by this method, and indeed three suggested conditions are provided which are directly relevant. (It is interesting to note, however, that one of the suggested conditions is followed by a statement that a remedy is available under the Noise Abatement Act, 1960, for undue noise or vibration - in fact the Act (now defunct) suffered from a greater lack of general application than does the Control of Pollution Act). Although now almost 15 years old the Circular is still current.

Further guidance was issued in 1973; the Circular 'Planning and Noise'(5) specifically stated that the criteria it contained would form the basis on which the Secretary of State would be guided in taking planning decisions which involved noise from roads, aircraft and industry. It may appear very strange to outsiders that the implications of such positive and reasonable advice given by Government almost ten years ago still need to be explained to officers and members of local authorities in order to justify the application of simple planning conditions to deal with noise. Current proposals to update and reissue the circular may result in more ready acceptance of its contents because of its novelty (to some).

There are distinct advantages in seeking to control noise by the imposition of correctly framed and valid planning conditions which may be summarised thus:-

ADVANTAGES OF NOISE CONTROL BY PLANNING

1. Controls may relate to the 'risk' of noise nuisance.
2. Restrictions on types of activity may be imposed.
3. Controls may restrict noise sensitive development.
4. Construction and layout of development may be controlled.
5. 'Personalised' consents may be granted.
6. The applicant is made 'noise-aware' at an early stage.

There are of course several disadvantages and where these are significant in terms of the overall objective of noise prevention, more effective measures may need to be considered.

LIMITATIONS ON NOISE CONTROL BY PLANNING

1. Only developments requiring planning permission are subject to control.
2. Enforcement procedures under the Planning Acts for breach of consent or conditions are long and uncertain.
3. The "Use Classes Order"(6) and "General Development Order"(7) permit certain developments automatically.
4. Condition (in general) can only relate to the application site.
5. Detailed conditions may require substantial monitoring to ensure or maintain compliance.
6. Little account is taken of intensification of use.
7. Conditions are valid for all time.

Recent advice from the Secretaries of State is contained in a Circular entitled "Development Control - Policy and Practice"(8). Whilst urging planning authorities to change the emphasis of priority from housing development to industrial and commercial applications, and requesting that decisions be made with speed and efficiency, it also advises that, inter alia, noise problems should not be overlooked in the interest of expediency. It is often the case, however, that the developer creates the bottleneck by failure to recognise potential problems due to inadequate prior consultation and research. Thus, planning conditions properly attached to consents are often overlooked and, when 'found', cause considerable surprise and, sometimes, acrimonious debate.

Were architects, industrialists and other development agencies to pay as much attention to the planning process as to the physical properties of the proposed development itself, such occasions would be minimised. In 1978, the National Building Agency, on behalf of the DoE and Welsh Office, issued a guide to planning permissions(9). The advice contained therein (although in part not in line with current legislation) relates to industrial developments and is both practical and logically laid out. The booklet should be compulsory reading for all intending developers as it sets out in no little detail the principal matters to be covered and the need for the creation of a good contact with the planning authority. The value of informal consultations with the authority prior to submission of an application is stressed: in view of the subsequent introduction of charges for development applications it is perhaps surprising that this aspect is not more often recognised.

CONCLUSIONS

Many local authorities, if not all, now seek to prevent noise pollution arising from new developments. Recent advice from local authority associations and central government has been interpreted in a way tending to imply that such controls should be severely restricted in application. It is held that such interpretations are incorrect and that, especially in the case of pollution by noise, use of powers to refuse or condition consents is a proper application of the planning process.

Arguments relating to alleged duplication of powers are erroneous: many pollutants, and some types of noise pollution, fall outside the supposed alternative powers. In any case, such powers usually relate to matters of health and safety or nuisance, and are not concerned with questions of amenity. Amenity itself is a heavily subjective term which can apply to many aspects of a planning application, and although as equally lacking in precise definition as the term nuisance, is clearly one which is to be considered during the planning process. Sufficient evidence has been adduced elsewhere to indicate that of all objections to proposed industrial or commercial development, those which refer to direct or consequential noise production are becoming increasingly common. Whilst it is rare to find refusal of consent on noise grounds alone, the imposition of controlling conditions has become normal practice for many local authorities.

Environmental Health Departments should ensure that they become involved in the planning process as a natural progression in the pollution control procedures. Equally, however, they must constantly be aware of the limitations of such processes and assure themselves and their planning colleagues of the validity of any conditions suggested.

Note: The views expressed in this paper are those of the author and do not necessarily reflect the policies of the Council of the City of Manchester.

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REDUCTION OF NOISE FROM HEAVY COMMERCIAL VEHICLES: THE TRRL QUIET HEAVY VEHICLE PROJECT

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1. INTRODUCTION.

Traffic noise is the most widespread and probably the most disliked form of noise pollution. Research at TRRL and elsewhere (1,2) has shown that at least 23 per cent of the residential population were bothered by it and 8 per cent were seriously bothered. More recent research on nuisance from heavy lorries suggested that of people in their homes, 12 per cent were bothered very much or quite a lot by lorries, although factors other than noise were taken into account in this survey.

Of the various approaches to the solution of this problem, which include road design, insulation of buildings, route and traffic flow control and land use planning, the most direct would be the introduction of quieter vehicles.

This would clearly reduce traffic noise but we need to know which vehicles should be quietened to achieve the greatest effect and what target noise levels are feasible.

This paper will discuss the background to vehicle noise reduction in the context of European legislation, examine the effects on traffic noise of changes of noise level in individual vehicle classes, in particular the heavy diesel-engined commercial vehicle, and go on to discuss the causes of vehicle noise and the means to reduce their effect. This latter it will do by describing a successful example of quietening the heaviest and noisiest class of goods vehicle, the TRRL Quiet Heavy Vehicle Project.

2. VEHICLE NOISE LEGISLATION.

Noise levels produced by vehicles are governed in the UK by the 'Motor Vehicle Construction and Use Regulations', the most recent of which (due in 1983) will embody the recommendations of the EEC Directive 77/212/EEC. For the heaviest commercial vehicle class the Directive calls for 88dB(A) (91dB(A) before) with values ranging down to

81dB(A) for light goods vehicles not exceeding 3.5 tonnes and 80dB(A) for passengers cars (84dB(A)). For reference, a reduction of 10dB(A) represents a halving of subjective loudness.

These limits apply throughout the European Community and refer to the vehicle noise produced under a standard test procedure (70/157/EEC(3), BS 3425:1966(4), or ISO R 362(5)). In these tests the vehicle is driven in the specified gear and engine speed towards the test site. Maximum acceleration is then applied over a distance of 20 metres past a microphone which is set at 7.5m from the vehicle centre line, 10m from the start of acceleration and 1.2m above the ground.

The Council also resolved in 1977 that efforts should be made to achieve a noise level of around 80dB(A) for all categories of vehicle by 1985. This now seems unrealistic and it has been suggested that it may take as long as until 1990 to get agreement, with implementation in 1995.

3. EFFECT ON TRAFFIC NOISE.

Given that the noise of individual vehicles can be reduced over time, it is important to know what effect this would have on overall traffic noise. An analytical procedure, developed by Nelson(6) at TRRL has been used to predict the reduction in L_{10} (the noise level in dB(A) exceeded for 10 per cent of the time in an 18 hr day), for different traffic flows and for future years, given the introduction of the lower vehicle noise standards called for in the 1977 EEC Directive.

Some results are given in Table 1 and the values shown assume that the noise limits specified in the EEC Directive were implemented in 1980 and that all vehicles entering service after that date would meet the standard levels. This was assumed to be followed by a further statutory reduction in vehicle noise in 1985 to achieve 80dB(A) for all vehicles.

Although these figures are illustrative only, they show that worthwhile reductions in L_{10} can be achieved by progressive reductions in noise emission standards provided, of course, that the vehicle industry is in possession of the requisite technology to design and produce vehicles that would meet the intended noise emission targets. Also the benefits tend to take a long time to develop.

4. HEAVY VEHICLE NOISE.

Although usually forming a comparatively small proportion of the total traffic flow, heavy diesel-engined goods vehicles are individually the noisiest type of vehicle and hence contribute disproportionately to traffic noise. Also they represent the most difficult problem in noise reduction because they have the most powerful (and hence noisiest) engines and there is comparatively little space for noise reducing components. Table 2 shows some typical 'in-use' noise levels.

For these reasons most research effort on vehicle noise reduction, in the UK at least, has been directed towards this class of vehicle.

4.1 Noise sources and their relative importance.

The sources of vehicle noise have been identified as engine, air inlet, exhaust, cooling fan, transmission, aerodynamic, road surface/tyres (rolling noise), brakes, body rattles, and load(7). This paper will not consider the last three but will concentrate on the causes and possible solutions to the main vehicle components sources and rolling noise.

The relative importance of these sources depends on the type of vehicle and the operating conditions. With light vehicles the engine is dominant only at low road speeds and acceleration in low gears; at higher road speeds in top gear with reduced engine speed and power, tyre noise is likely to be the dominant source.

However, with heavy diesel-engined lorries the engine, exhaust and cooling fan noise are the dominant sources under most operating conditions although the noise of the tyres rolling on the road surface can be noticable at high speeds.

Internal cab noise is also a problem with commercial vehicles and much effort has been directed by the manufacturers to reduce this as of course for the driver the cab is his 'place of work'.

Because the separate noise sources combine logarithmically to produce overall vehicle noise, it is imperative that all main noise sources are reduced together; little or no noticable improvement is made if, say, exhaust noise is reduced by half when the engine is left untreated.

Thus any viable programme of vehicle noise reduction has to take into account every important noise source.

5. RESEARCH INTO NOISE REDUCTION: THE TRRL QUIET HEAVY VEHICLE PROJECT.

As a result of the investigations carried out by the Working Group on Research into Traffic Noise(8), the Quiet Heavy Vehicle (QHV) Project was initiated by TRRL in 1971(9,10,11). The QHV Project was aimed at demonstrating that practical heavy diesel-engined articulated vehicles could be produced with external noise levels some 10dB(A) lower than the 1971 values (i.e. down to about 80dB(A), about the level of a private car).

The overall aim of the project was to assist the British vehicle industry to meet future legislation on maximum noise levels, and to demonstrate which levels are reasonable, having regard for the likely extra costs involved.

The principal objective was to enable vehicle manufacturers to produce demonstration quiet articulated vehicle tractors. The first was based on a Leyland vehicle with a gross vehicle weight limit of 32.2 tonnes and an engine of 158 kW. The second was a Foden vehicle designed for a maximum gross vehicle weight of 44.7 tonnes and fitted with a Rolls-Royce engine* of 262 kW. A target level of emitted sound of 80dB(A) was set to be achieved not only under the conditions of the standard BS 3425:1966 acceleration test, but also under any normal operating conditions. In addition to the external noise target the noise level in the driver's cab was not to exceed 75dB(A); the then current in-cab noise levels were around 92-94dB(A).

In order to achieve the overall target of 80dB(A) it was considered that the target levels for the major vehicle components should be as given in Table 3.

The research on the basic noise sources of the vehicles, including the design, construction and testing of quieter components, was carried out at the Institute of Sound and Vibration Research (ISVR) of Southampton University, the Motor Industry Research Association (MIRA), and the National Engineering Laboratory (NEL). The TRRL undertook the work on tyre-road surface noise and the overall management and coordination of the project. The allocation of the tasks is shown in Table 3. Important objectives were that the experimental components should be commercially practicable, and that the differences in production and operating costs should be evaluated for various degrees of quietening. To this end the close cooperation of the manufacturers was essential.

The QHV project was divided into two main phases: (i) the research phase which would lead to experimental versions of the two vehicles; and (ii) a development phase leading to commercially viable vehicles for demonstration. Both the experimental vehicles were produced, but only the Foden/Rolls-Royce vehicle was developed to demonstration form. The results obtained from the Leyland vehicle were to be used in future product designs.

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*Rolls-Royce were subcontractors to Fodens Limited.

The following is a summary of the research and development of the Foden/Rolls-Royce vehicle.

6. THE FODEN/ROLLS-ROYCE VEHICLE

6.1 Complete vehicle

The original Foden vehicle used at the start of the project was a 6x2 tractor unit with a 13 litre Rolls-Royce diesel engine, details of which are given in Table 4. MIRA and ISVR carried out work on the exhaust, cooling system, and cab noise of the vehicle until it was superseded by a later design based on a 4x2 chassis with a maximum gross vehicle weight of 38 tonnes.

When Fodens were preparing this vehicle they built into it the revised designs of cooling and exhaust systems then reached by ISVR and MIRA, provided a new design of cab with improved sound insulation, and fitted the engine with an improved turbocharger and camshaft, both of which gave useful reductions in open pipe exhaust noise emission. The final experimental version of the Foden vehicle included the quietened exhaust and cooling systems produced by MIRA and the quietened ISVR/Rolls-Royce 'research' engine in a tunnel enclosure. In this condition the vehicle was evaluated and returned to Fodens for the development phase of the project.

6.2 Engine

To establish the original (baseline) noise levels of the Rolls-Royce engine, the engine and gearbox were installed in an anechoic test cell at ISVR and coupled to a dynamometer to absorb the power.

To assess the relative importance of different parts of the engine surface as noise radiators, the entire engine was covered with lead sheet lined with glass fibre matting.

The noise level of the engine was measured with the individual components exposed in turn. Although this is not an accurate method of measuring the absolute noise output of any individual component (the noise of the completely enclosed engine was only 10dB(A) below that of the uncovered engine) the method is of value in establishing a rank order of the strength of the various sources. The rank order of components for this engine was (1) structure (cylinder block and crankcase), (2) sump, (3) front end, (4) gearbox, (5) air inlet. The frequency spectrum of the engine is shown in Fig. 1. This work, together with a vibration survey of the engine surface and static bending tests, led to the design of the research engine at ISVR.

The basic philosophy of the research engine was to use the running gear (pistons, connecting rod, crankshaft etc.) from the standard engine in a strenghened cylinder block/crankcase structure. This reduced the flexing of the cylinder block walls caused by the distortion of the crankcase. Another requirement of the crankcase design was to provide flat sides to enable close fitting damped panels to be attached for the attenuation of transmitted vibration. The fuel pump was replaced by a quieter version and the sump was isolated from the engine by a thick U-section rubber moulding. The sides and front surfaces of the engine were fitted with laminated damped panels consisting of a central sheet of steel perforate and outer sheets of mild steel sandwiched together with layers of Neoprene.

Although the target noise level was not quite reached at maximum load and speed, the final noise level was nearly half that of the standard engine. The spectra of the overall noise are shown in Fig. 1, and the ISVR/RR research engine is shown in Plate 1 on test at ISVR.

6.3 Exhaust

The open pipe exhaust noise level from the Rolls-Royce engine was 109dB(A) at 2100 rev/min with the microphone

7.5 metres from the end of the pipe and 60 degrees off the axis. Before the work on the silencers started this noise level was reduced by the fitting of an improved turbocharger (-3dB(A) at higher speeds), and a modified camshaft with different valve clearances (-6dB(A) to -8dB(A)).

ISVR produced computer-based designs from engine exhaust data supplied by MIRA from their engine tests. MIRA then used the ISVR basic designs to produce practical versions and tested these in a special noise test facility.
A total of 22 versions of the experimental silencers were built and tested and an important aim throughout the work was to achieve the required noise attenuation using entirely reactive elements in the final design. Sections including absorption material would become clogged with exhaust products and the material blown out of the systems with consequent loss of performance.

The final design was completely reactive and consisted of two cylindrical boxes with a total volume of 186 litres. It met the target of 69dB(A) at 7.5m on the basis of a spatial average but exceeded the dB(C) target by 2dB(C) at high engine speeds; at low engine speeds the dB(C) level was short of the target by a larger margin due to difficulty in silencing the engine firing frequency components.

6.4 Cooling system.

Measurements of noise made with original cooling system, which used an axial fan running at up to 2400 rev/min, showed that reduction of noise of the order of 25dB(A) would be needed to meet the project target of 84dB(A) at 1m in front of the fan. Using the existing fan would have meant a reduction in fan speed of 1500 rev/min; an unacceptable solution in terms of cooling performance.

A centrifugal fan was selected for the initial design as likely to meet the target noise and cooling requirements. The fan duty was considerably increased compared to the original system by the need to drive cooling air through the engine enclosure.

The experimental cooling system was tested on a specially designed rig at MIRA and although the results indicated that its noise and cooling performance should have been within the target values, when it was installed in the vehicle the cooling performance was well below that required. It became clear that this was due to the restricted space available for the cooling system which resulted in a loss in fan and radiator performance; the radiator matrix was very close to the fan which caused uneven distribution of the cooling air across the matrix.

The problem proved insoluble with that design and eventually a new cooling system based on a mixed flow fan designed by the National Engineering Laboratory in cooperation with IME Marston Radiators provided the required noise and cooling performance.

6.5 Tyres

The research on tyre noise at TRRL(12) led to the recommendation that the research vehicle, and also the demonstration vehicle, be fitted with radial tyres having five or more circumferential ribs and no pronounced edge patterns.

6.6 Summary of research on Foden/Rolls-Royce vehicle

The maximum external noise level of the final research vehicle was reduced to 83.5dB(A) and the cab noise to 78dB(A). This result was achieved by a combination of quietening measures on the basic vehicle components. The ISVR/RR research engine emitted noise levels about 9-10dB(A) less than the standard engine; the final silencer design produced a noise level which met the dB(A) target and at high engine speeds came within 2dB(C) of the target; the cooling package based on the centrifugal fan met the noise target at its design speed but could not meet the requirements of the maximum ambient temperature. A new cooling system based on a mixed flow fan met both the noise and cooling targets. The spectra of the unmodified and research vehicles are compared in Fig. 2.

7. THE DEMONSTRATION FODEN/ROLLS-ROYCE VEHICLE.

After the research vehicle had been completed and tested at MIRA in 1976, it was handed over to the manufacturers, Foden and Rolls-Royce, for a two year period of development work. The final demonstration vehicle (Plate 2) was publicly demonstrated on 22 November 1978.

The vehicle included a version of the quiet Rolls-Royce engine built to production standards, commercially made examples of the silencers, the new cooling system and other components.

The engine and gearbox were screened by an enclosure which was designed to minimise interference with normal access and maintenance. The upper part of this enclosure was designed to be raised automatically when the cab was raised and in this position it would be possible to do all day to day maintenance and also remove the engine without removing the enclosure (Plate 3).

The external noise of the vehicle had been reduced to 79dB(A) (70/157/EEC) and 81dB(A) to BS 3425, 1966, and the cab noise to an overall value of 72dB(A) under normal operating conditions (75dB(A) under acceleration in low gear). The cooling fan contributed no more than ½dB(A) to total vehicle noise.

The overall cost and weight penalties incurred in the demonstration vehicle by the modifications to reduce noise were a 7.3 per cent increase in first cost and a 0.6 per cent increase in gross weight.

8. OPERATIONAL TRIALS.

In order to evaluate the durability of the vehicle's noise reduction measures, to assess the running costs and to discover any special problems involved in maintaining and operating the vehicle, the QHV was placed with a haulage contractor for an extended operational trial of two years duration(13). This work showed that, generally, the QHV operated satisfactorily during the period of the operational trial.

The vehicle travelled over 116,000 km in this period and carried over 11,000 tonnes of payload, the maximum payload being carried on approximately 25 per cent of all journeys. Thus the vehicle was worked normally for its class and the fuel consumptions achieved in use were broadly similar to those obtained from similar unmodified articulated vehicles.

Maintenance and servicing costs were increased as a result of the noise quietening features on the vehicle by 1.5 per cent. This increase represents about 0.2 per cent increase in the total operating cost.

Benefits from the operation of this type of vehicle are difficult to quantify but include a high level of driver acceptibility due to low cab noise and the high power to weight ratio which gave good acceleration and drivability characteristics.

The subjective impression given by the vehicle was of quietness and smoothness and wherever the vehicle was driven in the day to day business of the haulier the driver reported frequent and consistently favourable comments about the noise emission characteristics; in particular the exceptionally quiet idling condition was noted.

9. ACKNOWLEDGEMENTS.

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TABLE 1

Reductions in L_{10} dB(A) for future years following the implementation of statutory vehicle noise reductions in 1980 and 1985

Forecast Year	Reduction in L_{10} dB(A) with 10% Heavy Lorries *	 20% Heavy Lorries *
1980	0	0
1985	0.8	0.4
1990	3.9	4.0
1995	6.3	7.2

* Figures are reductions in L_{10} following the implementation in 1980 of the EEC Directive 77/212/EEC and with vehicle noise limits for all categories reduced to 80 dB(A) from 1985 onwards. A traffic flow of 2000 veh/hr is assumed.

TABLE 2

Some ' in-use ' noise levels of current heavy vehicles

Vehicle	Max gvw tonnes	External noise dB(A) (unladen BS test)	Internal cab noise dB(A) (at max power speed)
1	35	91	82½
2	32.5	93	-
3	35	93½	82
4	32.5	89	82
5	32.5	86½	83
6	38	88	82
Foden/Rolls Royce demonstration vehicle	38	79/81	72-75

TABLE 3

Upper limits of sound levels to be emitted by vehicle components

Research organisation*	Noise source	Maximum level dB(A) at 1m	at 7.5m
ISVR	Engine including gearbox	92	77
	Air intake, exhaust system (computer modelling)	84	69
MIRA*	Cab noise	——— 75 dB(A) ———	
	Cooling system	84	69
	Exhaust system (development of practical systems)	84	69
NEL	Final cooling fan design		(additional target of 90 dB(C))
TRRL	Tyre-road surface noise	—	75—77

* MIRA were to design the vehicle cab to provide 3 dB(A) attenuation of the sound level emitted to the roadside by the power unit

TABLE 4

Details of the Rolls Royce diesel engine

Cycle/Aspiration		4. Turbocharged
Cylinders:	number	6
	arrangement	in line
	inclination	vertical
	bore	135.0 mm
	stroke	152.4 mm
	capacity	13.09 L
Max power		262kW (352 b.h.p.)
Max power speed		2100 rev/min
Max b.m.e.p.		182 lbf/in^2 (186 lbf/in^2)*
Boost pressure at max. power		18 lbf/in^2 (21 lbf/in^2)*
Exhaust back pressure (max)		51 mm Hg

* figures in brackets are for the engine with later turbocharger and camshaft

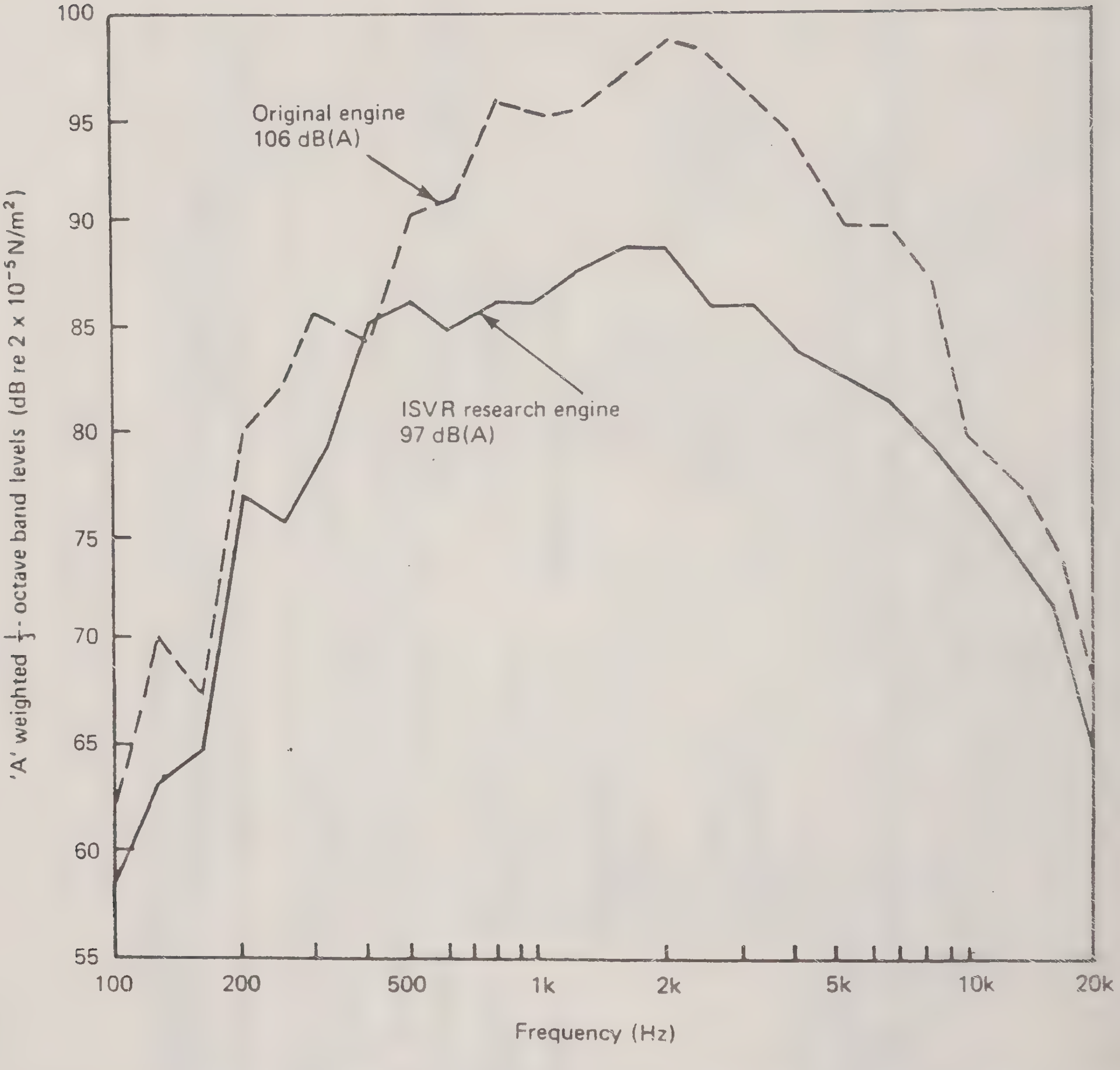

Fig. 2. Comparison of the noise emitted by the unmodified and 'research' Foden/Rolls Royce vehicle (With the research engine)

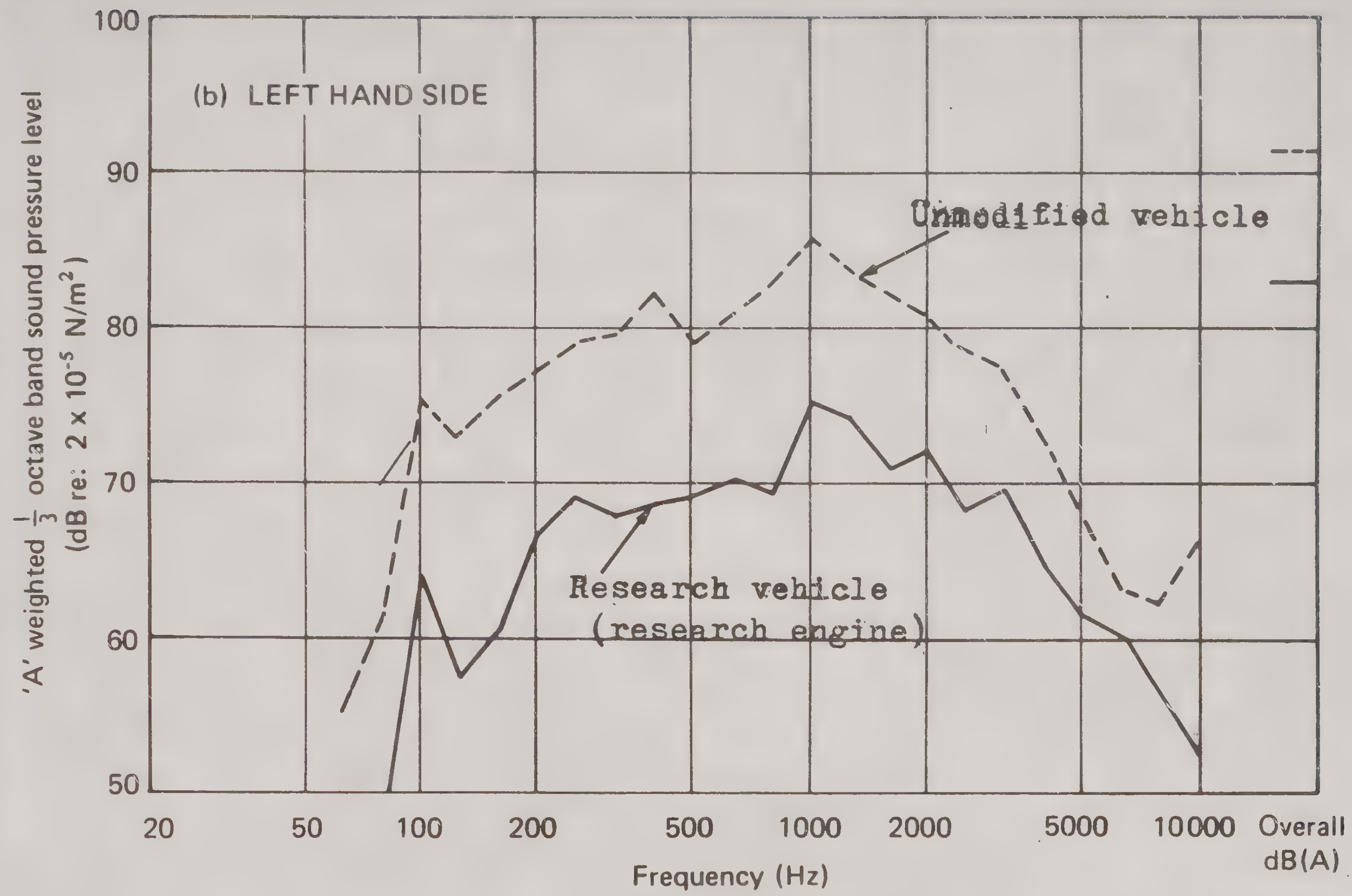

Fig. 1. Comparison of spectra of original and research Rolls Royce Eagle engine at rated conditions (nearside)

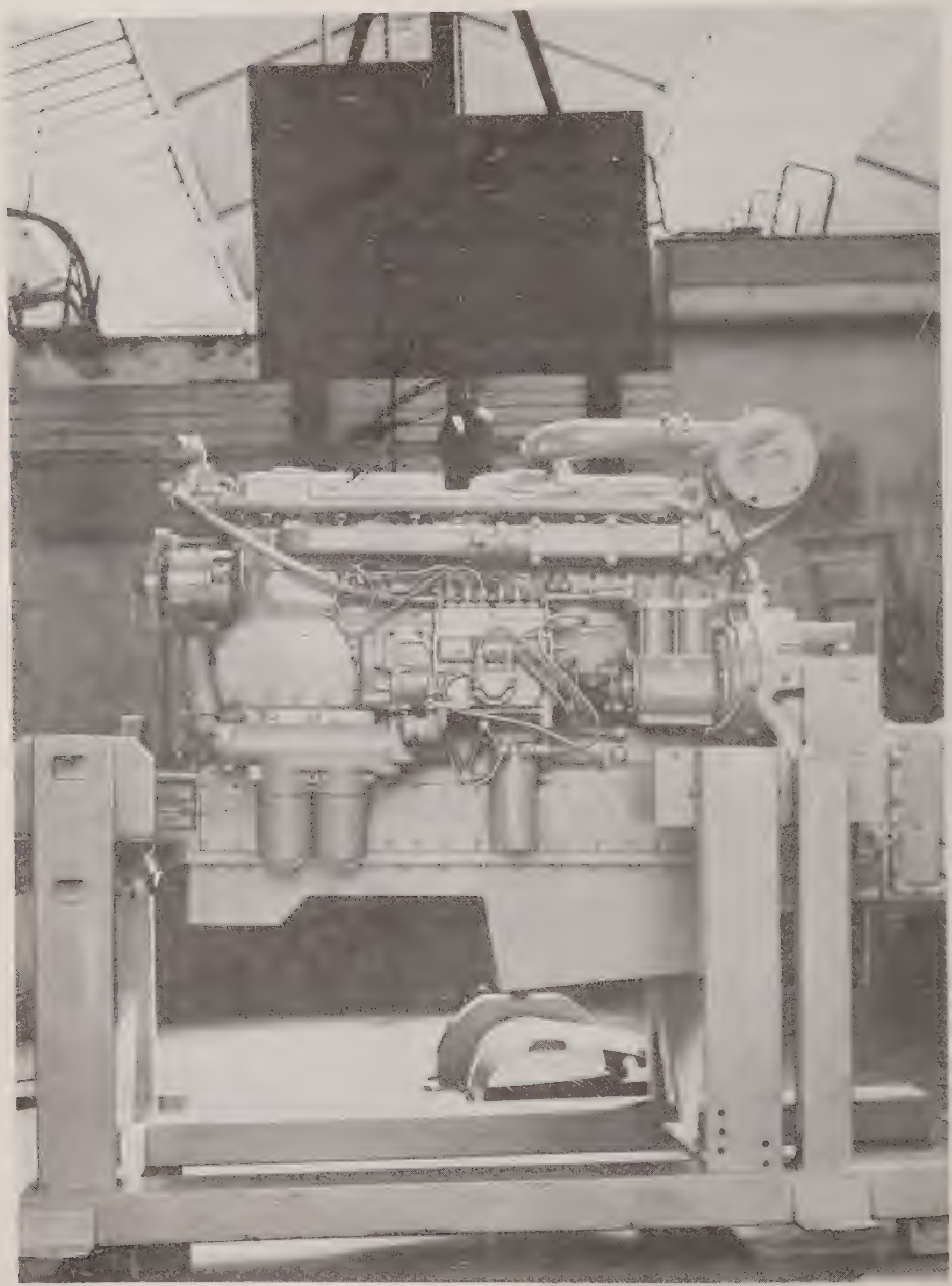

PLATE 1. ISVR/Rolls Royce research engine on the test bed at the Institute.

PLATE 2. The TRRL Quiet Heavy Vehicle in operators livery while undergoing operational trials.

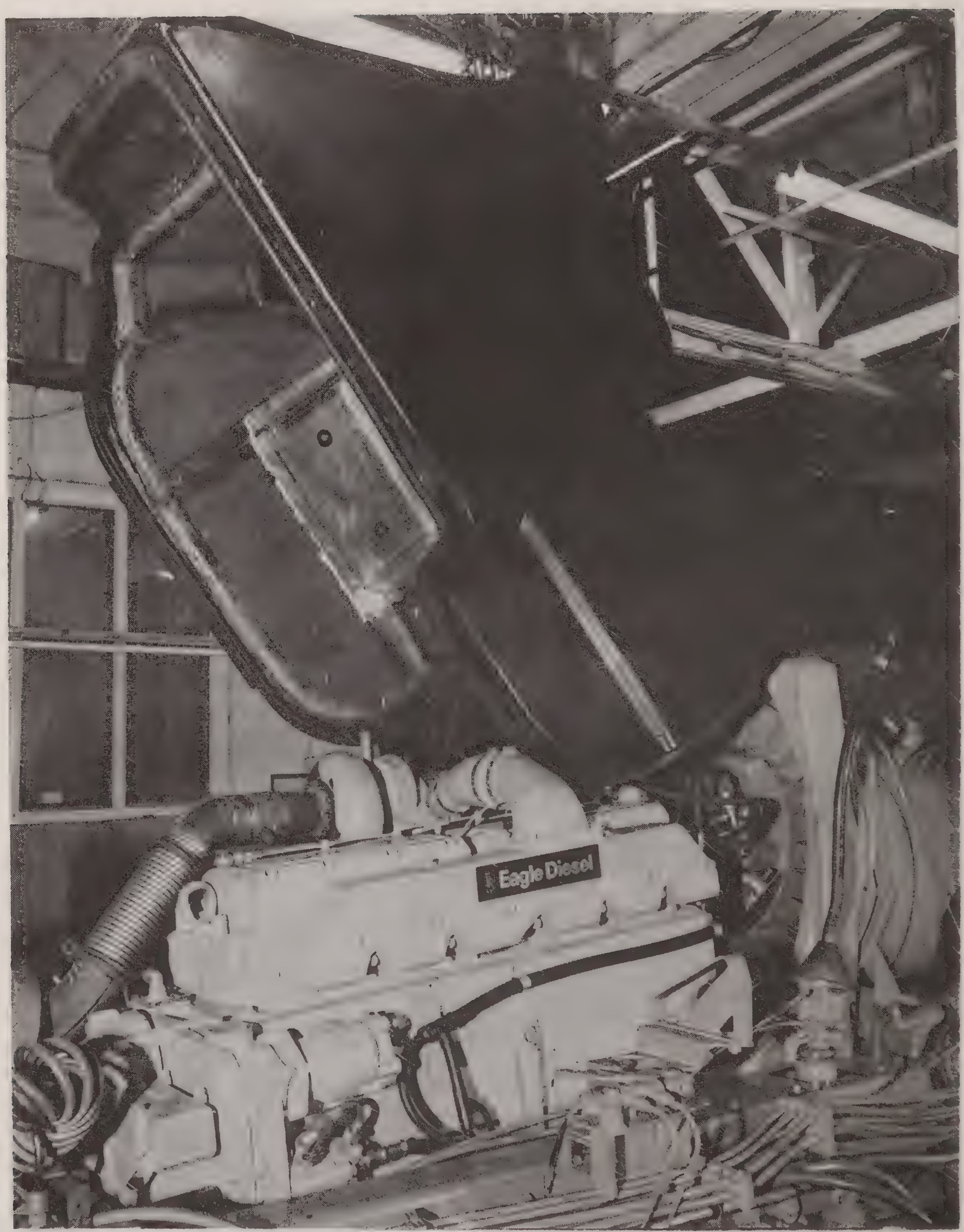

PLATE 3. View of demonstration vehicle showing Rolls Royce Quiet engine; upper enclosure in 80% raised position (cab removed); cooling fan stator and hydraulic drive

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THE CONTROL OF NOISE FROM CONSTRUCTION SITES

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1. INTRODUCTION

This paper is about the control of noise from construction sites. After a brief introduction to the subject, the paper discusses planning for noise control on construction sites and noise control on sites already in existence and gives a case study as an example.

Construction activities are inherently noisy and often take place in areas which are quiet before the construction activity commences and which will be expected to be quiet again after the construction activity is complete. It is this introduction of noisy activities into otherwise quiet and possibly noise sensitive areas which has made construction site noise one of the main areas of interest for environmental noise pollution. The control of construction site noise is made difficult because of the following factors:

a) The plant used on a construction site varies considerably from one phase of a project to the next and plant usage and proposed methods of working are difficult to predict before the construction project commences.

b) Most construction activities will involve a large number of sub-contractors in addition to the main contractor. The sub-contractors might be involved in the project for only a short time and might well be less concerned with the effect of their activities on the surrounding environment than the main contractor.

c) Construction activities are only of limited duration and the local community might well have a vested interest in seeing the building etc. constructed as quickly and cheaply as possible, i.e. the community response to the construction noise can depend on what is being constructed.

The responsibility for controlling construction site noise lies primarily with the local authority via their Environmental Health Department although specifiers for large contracts, for example the Department of Transport for major road constructions, might include construction noise control requirements in the contract specification.

Before looking in detail at the control of noise from construction sites it is necessary to know a little about the specialist units used for noise measurement and these will be discussed in the next section.

2. NOISE UNITS

Normally noise measurements are made and noise limits are set in units of dB(A) Leq. This section attempts to explain what these units are and why they are used.

Sound is the transmission of energy through the air as pressure waves. The amount of energy transferred by sound waves in any particular direction is referred to as the acoustic intensity and has the units W/m^2. Until very recently it has been impossible to measure acoustic intensity directly, although now microprocesser controlled measuring instruments are coming onto the market. These units however cost many thousands of pounds and they are unlikely to be used outside specialist acoustic research laboratories. Normally an estimate of the sound intensity of a sound wave can be obtained by measuring the sound pressure; this is the average value of the magnitude of the pressure changes which occur when a sound wave travels through air. Also the ear responds not to acoustic intensity but to sound pressure. It is sound pressure which is measured by common sound measuring instruments such as sound level meters. This sound pressure could be presented directly in pressure units but a measuring scale has been devised which is based on the subjective response of the human being to sound pressure. The units of this scale are known as A-weighted decibels and are given the symbol dB(A). The dB(A) is related to the average sound pressure by the following equation:

$$L_A = 10 \log_{10} \frac{p_A^2}{Po^2}$$

where L_A = sound level in dB(A)

P_A = average frequency weighted sound pressure

Po = reference sound pressure of 2×10^{-5} Pa

The square of the sound pressure appears in this equation because sound energy in air is proportional to the square of the sound pressure. Also the ear is not equally sensitive to all frequencies hence a frequency weighting, called 'A' weighting, similar to that of the ear, is applied to the noise signals.

On the dB(A) scale the value of 0 corresponds to just less than the quietest sound which the average human being can hear; a value of 30 would correspond to the noise level in an urban bedroom at night; values of 50-60 would be found in the average living room or office; a value of 100 would be a sound level which most people begin to find unpleasant and a value of 120 corresponds to a level which most people would find painful.

In general it is found that if people are asked to rate noise levels on a scale where 0 represents absolute silence and 100 represents a sound which is so loud as to be unpleasant, then their ratings will correspond approximately to the dB(A) value given by a sound level meter. This makes the dB(A) scale an extremely useful one for assessing human response to noise but, because it is a logarithmic scale, it means that mathematical manipulation of dB(A) levels, for example additions of sound levels or the prediction of the reduction of noise levels with distance, are not as straightforward as they would be if the linear scale were used for giving noise levels. It is normally necessary to convert the dB(A) level back to its energy (i.e. pressure squared) value before performing any mathematics.

Sound levels from most activities fluctuate and on many occasions it is useful to be able to average the fluctuating levels in a given time interval to obtain a single figure average value. This averaging can be done in several ways. If the arithmetic average of the changing dB(A) levels is taken, the average obtained is termed L_{Amean}; however, this form of averaging is very little used. A figure which is normally numerically very close to L_{Amean} is L_{A50} and represents the level exceeded for 50 per cent of the time, i.e. the median rather than the mean value. Other percentage indices can be obtained such as, for example, L_{A10} or L_{A90}, which are the levels exceeded for 10 per cent and 90 per cent of the time respectively. The method of averaging fluctuating sound levels which has gained the greatest acceptance for construction site noise is the so called L_Aeq. This is the value in dB(A) of the average of the sound pressure squared. Because the dB(A) scale is logarithmic scale the numerical value of L_Aeq is normally larger than that of L_{A50} and L_{Amean}. One advantage of L_Aeq is that it is easier to make predictions in terms of this average value than with other means of averaging sound levels. There is no evidence to show that other methods of averaging correlate better with subjective reaction, at least for the type of noises encountered in construction. To summarise therefore:

a) The ear responds to sound pressure.

b) It can be shown that sound energy is proportional to the square of the pressure.

c) A scale based on the logarithm of the frequency weighted square of the sound pressure, called the dB(A) scale, has been shown to correlate well with people's subjective assessment of noise level.

d) Long term averages of the square of the fluctuating sound pressure expressed on the same dB(A) scale and called L_{Aeq} have been found to be the most appropriate method of averaging construction site noise over an extended period.

3. PLANNING FOR NOISE CONTROL

Noise emission limits are often set for construction sites before any on-site activity commences. These limits might be stated in the specification for the contract but are more likely to come from the local authority under powers granted by the Control of Pollution Act 1974. It is therefore of interest to look at the working of this Act and also at other official guidance on noise limits for construction activities.

3.1 The Control of Pollution Act 1974 and the Code of Practice for Noise Control on Construction and Demolition Sites, BS 5228:1975

Part 3 of The Control of Pollution Act deals exclusively with noise and Clauses 60 and 61 refer specifically to the noise from construction sites. Where construction operations are going to be carried out, the local authority may serve a Noise Abatement Notice on a contractor specifying one or more of the following:

a) Plant or machinery which is, or is not, to be used.

b) Hours during which work may be carried out.

c) Noise levels which may be emitted.

d) Provide for any change of circumstances.

However, in specifying any of the above the local authority should have regard to:

a) Relevant Codes of Practice issued under this part of the Act.

b) The need for ensuring that the best practicable means are employed to minimise noise.

c) Before specifying plant or machinery, to the interest of the recipient.

d) The need to protect any persons from the effect of noise.

Any person served with such a Notice may appeal within 21 day of receipt.

The other approach, outlined in Clause 61, places the onus on the contractor or other responsible persons. In the section the contractor can notify the local authority of his methods of working and noise control procedures and apply for a consent. The local authority may grant such a consent or have the power to apply conditions to the consent.

The local authority should reply to applications for consent within 21 days; if this reply is not forthcoming or the conditions attached are not acceptable the contractor can appeal to a magistrates court within 21 days.

It is essential to the working of this legislation for both contractors and local authorities to have consultations prior to any of the formal procedures being entered into.

The Department of the Environment have issued a circular 2/76 entitled 'Control of Pollution Act 1974 implementation of Part 3 - Noise'. This document outlines the forms of notices and grounds for appeal, and in issuing any notice, the local authority should also send the following information:

a) An indication of the right to appeal, the time within which the appeal must be made, and the need to notify any person referred to in the Notice of Appeal within 21 days of receipt of a Notice.

b) The need to state the grounds of appeal.

c) The grounds of appeal that are specified in the Regulations.

d) Whether or not a notice served under Section 60 is to be suspended in the event of an appeal. If the notice is not to be suspended the local authority will explain the reason why.

e) Whether or not qualifications or limitations that apply to a consent, or the refusal to give a consent, are to be suspended in the event of an appeal.

A Code of Practice relevant to this part of the Act is the BSI Code of Practice for Noise Control on Construction and Demolition Sites, BS 5228:1975. The declared aim of the Code of Practice is to recommend methods of noise control in respect of building, civil engineering, construction and demolition works, to enable local authorities, developers, architects, planners, designers, contractors and engineers to control noise. The Code gives information on protection of persons on site from noise and also gives methods of measuring and estimating noise from site plant and operations and gives advice on methods of reducing noise.

Neither the Control of Pollution Act nor the Code of Practice sets down specific limits for construction site noise, on the basis that the local authorities should know their own locality and have a better idea of suitable noise limits. However, in Appendix D to the Code it does state that generally it should be possible to limit the noise at a distance of 1 metre from the facade of a building during the day-time period (0700 - 1900) to an Leq of 75 dB(A).

4. THE PREDICTION OF NOISE FROM CONSTRUCTION ACTIVITIES

If noise limits have been set for construction activities at the planning stage, it is necessary to be able to estimate the likely noise emissions from the proposed construction activities to see what modifications, if any, are necessary to the preferred method of working, to comply with the limits set. Guidance on the prediction of noise from stationary plant is given in the Code of Practice BS 5228 and also in the Construction Industry Research and Information Association Report No 64, 'Noise from construction and demolition sites - measured levels and their prediction'. There is insufficient space available here to deal fully with noise predictions from stationary plant which are fully documented in the above two reports.

One aspect of noise predictions which is not dealt with in either of the above reports, however, is that from moving plant. During the preparation of the CIRIA Report mentioned above it was found that where predicted levels were in error it was largely due to the presence of moving plant and the difficulty of accurately predicting its level. Because of this, Wimpey Laboratories carried out work for the Building Research Establishment on the measurement and prediction of noise from moving plant. Moving plant was defined as anything from an air hose being waved from side to side to dump trucks and scrapers making long hauls. Based on analysis of the results an entirely empirical relationship was found between the distance ratio and equivalent percentage on-time which are defined as follows:

$$\text{distance ratio} = \frac{\text{plant traverse length}}{\text{distance of closest approach of plant to measurement position}}$$

Equivalent percentage on time

$$= \frac{\text{average sound intensity at measurement position}}{\text{sound intensity due to plant at distance of closest approach}} \times 100$$

The empirical relationship between the distance ratio and the equivalent percentage on-time is given in table 1. If this relationship is compared with the very simplest theoretical analysis a large discrepancy is noticed as can be seen in figure 1. If a typical stop time is included at the end of the traverse then the agreement with theory is better for distance ratios above 3 but there is still a discrepancy below; a discrepancy which cannot be satisfactorily explained. The empirical relationship, when used for predictions, can give results which are accurate to within 2 dB. This prediction technique for moving plant is likely to be included in the revision of BS 5228. Although this method could be further refined on the basis of further measurements, it is the best method presently available for predicting noise from moving construction site plant.

5. NOISE REDUCTION

Methods of noise reduction for various items of plant and operations are given below. In the event that the noise control procedures outlined do not result in achieving the desired noise limit, reduction of the operation time may be the only method available.

The methods may be conveniently grouped under two headings - the control of noise at source and the control of noise propagation.

5.1 Control of noise at source

This is the preferred method of noise reduction, since it will also control the levels of noise for operatives.

a) Alternatives

A noisy item of plant or process should be, where reasonably practicable, replaced by a less noisy alternative. An example of this is plant driven by diesel engines; electric motors should be used in preference.

One of the areas in the construction industry which is considered to be the noisiest is piling. A comparison of alternative piling systems is given in table 2.

A comparison of alternative plant for drilling and concrete breaking is given in table 3. However, choice of an alternative operation is sometimes impossible due to ground conditions or restricted working area.

b) Modifications

Noise from plant can be reduced by modification, but should only be undertaken after consultation with the manufacturer. Where appropriate, equipment should be silenced and modifications may include improved engine exhaust silencers.

c) Enclosures

The source could also be totally or partially enclosed, providing care is taken to maintain the ventilation requirements of the item of plant. Where both the machine and operator are enclosed in an acoustic shed, it is necessary for the plant to be silenced and the operator to wear the appropriate ear protection, goggles and dust masks. However, an enclosure is only convenient when the source is stationary and a minimum amount of access is required for maintenance etc. More detailed information on the design, manufacture and performance of acoustic enclosures, sheds and screens is given in Appendix H of the 'Code of Practice for Noise Control on Construction and Demolition Sites'.

d) Use and siting

The use and siting of equipment, although an obvious noise control method, can with care alleviate problems with no increased cost. Noisy site equipment should be positioned away from noise-sensitive areas. Special precautions should be taken for night time operations in particular. Machinery which is not in constant use should be shut down or throttled down to a minimum during period of inactivity. Engine covers should be kept closed when the plant is in operation, e.g. compressors. Where this is not possible the plant should be orientated so that the side with the open panel is directed away from a noise sensitive area; this is also the case with plant emitting noise strongly in one direction.

The unloading and loading of materials on site should be carefully undertaken to achieve a minimum amount of noise. Haul roads should be selected to achieve the least amount of neighbourhood disturbance possible.

e) Maintenance

Regular and effective maintenance of plant is essential and will maintain noise levels close to those of new plant. Maintenance should always be carried out by trained personnel.

5.2 Control of noise propagation

If the reduction of noise at source cannot be achieved, then the amount of noise reaching the receiver should be controlled. This type of control includes increasing the distance between source and receiver or introducing noise reduction screens.

a) Distance

Increasing the distance may be the most effective method of noise control, but can only practicably be used for stationary items of plant, e.g. compressors and generators.

b) Screens

The introduction of noise reduction screens may be of more benefit on small sites, lacking in space. The construction of the screens could be of earth mounds or building structures, e.g. site offices or partially demolished buildings. The barriers or screens must be positioned as close to the source as possible for maximum effectiveness.

Earth barriers can be most effective when considering mobile items of plant on a haul road and for the screening of continually operating plant at night times, e.g. water pumps.

Wimpey Laboratories have carried out research for CIRIA on the performance of a smiple noise barrier constructed from materials which would be readily available on a construction site. Figure 2 shows one barrier unit. The effectiveness of barriers of various sizes constructed from these units in reducing the noise emitted by a 17 m^3/min compressor was measured. Figure 3 summarizes some of the measurements made and shows the attenuations provided by various sizes of barrier at distances of 16 m and more from the source. It can be seen that the attenuation varies from 5.5 dB(A) for a barrier that just screens the source, to 10.5 dB(A) for a barrier that screens the source well.

If noise reduction to a suitable level cannot be introduced by the methods outlined above, people who may be affected by the noise disturbance should be informed if noisy operations are going to take place. Communication can often reduce the incidence of complaints.

6. NOISE CONTROL ON EXISTING SITES

Although it is possible to consider noise control at the planning stage of a construction job, most cases which involve control measures being instituted on construction sites come about when the site is already in existence and complaints of excessive noise are made by nearby affected persons, usually residents or office workers. By the time that a construction job is underway it is more difficult to achieve noise control by optimum plant siting or by the use of less noisy plant. There will normally be strong pressure to avoid resiting large stationary items of plant and against bringing in alternative, less noisy, plant. Normally, enclosures or barriers are the best means available of reducing noise. A great deal can be achieved also by ensuring that everyone on site is made fully aware of the importance of not making unnecessary noise. It is a fact that no sound is more annoying than one which could obviously easily be avoided. To illustrate some of the points made a recent case where noise control was necessary on a construction site will be discussed.

Case study

The site involved was a city centre office development, shown in fig. 4. A noise abatement notice under Section 60 of the Control of Pollution Act had been served prior to commencement of works, requiring that work only be carried out between certain hours and also that the best practicable means be employed to minimise noise nuisance. The Notice was invoked following a complaint from a nearby office occupant that the general noise level from the site was making his work difficult, if not impossible. He found it difficult to identify a single specific item for complaint but stated that several sources of noise on the site were causing annoyance. The main contractor for the site was George Wimpey plc and so the Laboratory became involved in negotiations between the site management and the local authority to decide on what noise control measures could be instituted. Table 4 lists the problem areas which were identified and the general solutions employed. Noise measurements made by the local authority showed that these noise reduction measures had reduced the noise at nearby affected buildings by very approximately 10 dB(A), from between 65 dB(A) and 80 dB(A) to between 55 dB(A) and 70 dB(A). The main contractor also wrote to all sub-contractors currently or expected to be on site, stressing the need to avoid unnecessary noise, and supplied the original complainant and also a representative of the local residents with a timetable of future potentially noisy operations with forecasted completion dates. Because of the specific noise reduction measures instituted by the contractor and also the undertaking given by the site management that the need to minimise noise nuisance would be constantly borne in mind and given a high priority, the local authority was satisfied that the best practicable means were being used to reduce noise and therefore the noise abatement notice was withdrawn.

CONCLUSTIONS

1. Construction activities often take place in otherwise quiet areas and near noise sensitive buildings such as offices and dwellings. As many construction activities are inherently noisy, noise from construction sites can often be a problem.

2. The responsibility for ensuring construction noise control rests in general with the local authority under powers granted by the Control of Pollution Act 1974. A Code of Practice relative to the above Act is BS 5228 'Code of Practice for Noise Control on Construction and Demolition Sites'.

3. The main methods of reducing construction site noise are:

Use alternative quieter plant.

Site noisy plant to minimise noise propagation off side.

Use enclosures to reduce noise emission.

Use barriers to reduce noise propagation.

Reduce working hours.

4. Maintining good communications with persons affected by construction site noise can help to reduce complaints, as can the programming of unavoidably noisy activities to occur at the least noise sensitive parts of the day.

Table 1

Relationship of distance ratio and equivalent percentate on-time for slow moving plant

Distance ratio, (traverse length/ minimum distance)	Equivalent percentage on-time
0.5	100
0.7	80
1.0	63
1.5	50
2	40
3	32
4	20
5	16
6	13
7	10
8	10
9	8
10	8
10	6

Table 2

Comparison of alternative piling systems

Pile type	Driving method	Distance at which the Leq is 90 dB(A) m	Distance at which the Leq is 75 dB(A) m
Sheet steel	Diesel hammer	60	360
	Air hammer	22	130
	Screened drop hammer with dolly	1	10
	Jacked	-	4
Bearing piles (concrete)	Drop hammer	22	130
	Drop hammer with dolly	7	40
	Crane mounted auger	5	40
Retaining walls	Diaphragm walling	3	17

Table 3

Comparison of typical noise levels of alternative breakers and drills

Operation	Method	Leq at operator position in dB(A)	Distance at which the Leq is 90 dB(A) m	Distance at which the Leq is 75 dB(A) m
Rock drilling	Excavator mounted drill	108	8	50
	Down the hole drill	98	3	15
Concrete breaking (a) hand held	without muffler	102	4	25
	with muffler	96	2	12
	Acoustic shed (absorbent lined, with screen) without muffler	102	outside shed	6 m from shed
	Acoustic shed (absorbent lined, with screen) with muffler	96	outside shed	3 m from shed
(b) machine mounted	Excavator and hydraulic breaker attachment	86	6	40
	Excavator + BRE Nibbler	Estimated 83	approximately 1	10

Table 4

Main sources of noise nuisance	Solution employed
Concrete lorries discharging ready mixed concrete onto site directly below complainant's office window	Relocate discharge point at furthest practicable position away from window. (Approximately 20 m)
Dumper truck causing noise nuisance	Dumper trucks banned from street by offices except for access.
Noise from pneumatic drills breaking out concrete etc	To be screened wherever possible by simple timber screen and use to be limited as far as possible to times of highest ambient noise (morning and evening rush hours)
Noise from circular disc cutters	Discontinue use and employ burning or pipe cutting gear
Noise from circular saws	Surround with timber enclosures wherever possible
Tipping waste from skips into lorries	Discontinue this practice. Remove skips directly
Noise from compressed air cleaning guns	Screen wherever possible and restrict use to times of highest ambient noise as far as possible
Compressor mounted at 1st floor level on scaffold walkway	Relocate at ground level, screen by site hoarding.

COMPARISON OF RESULTS WITH THEORY

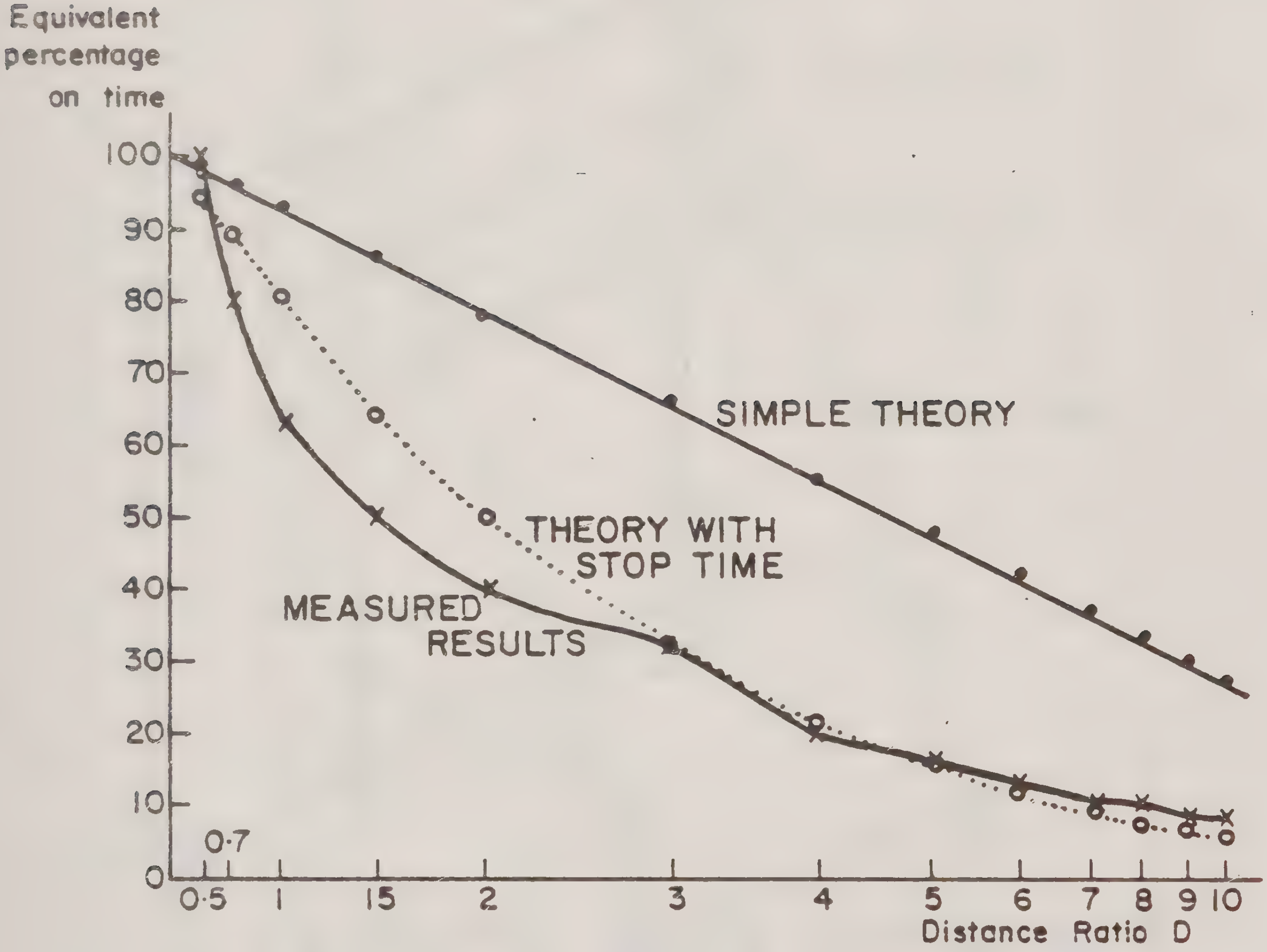
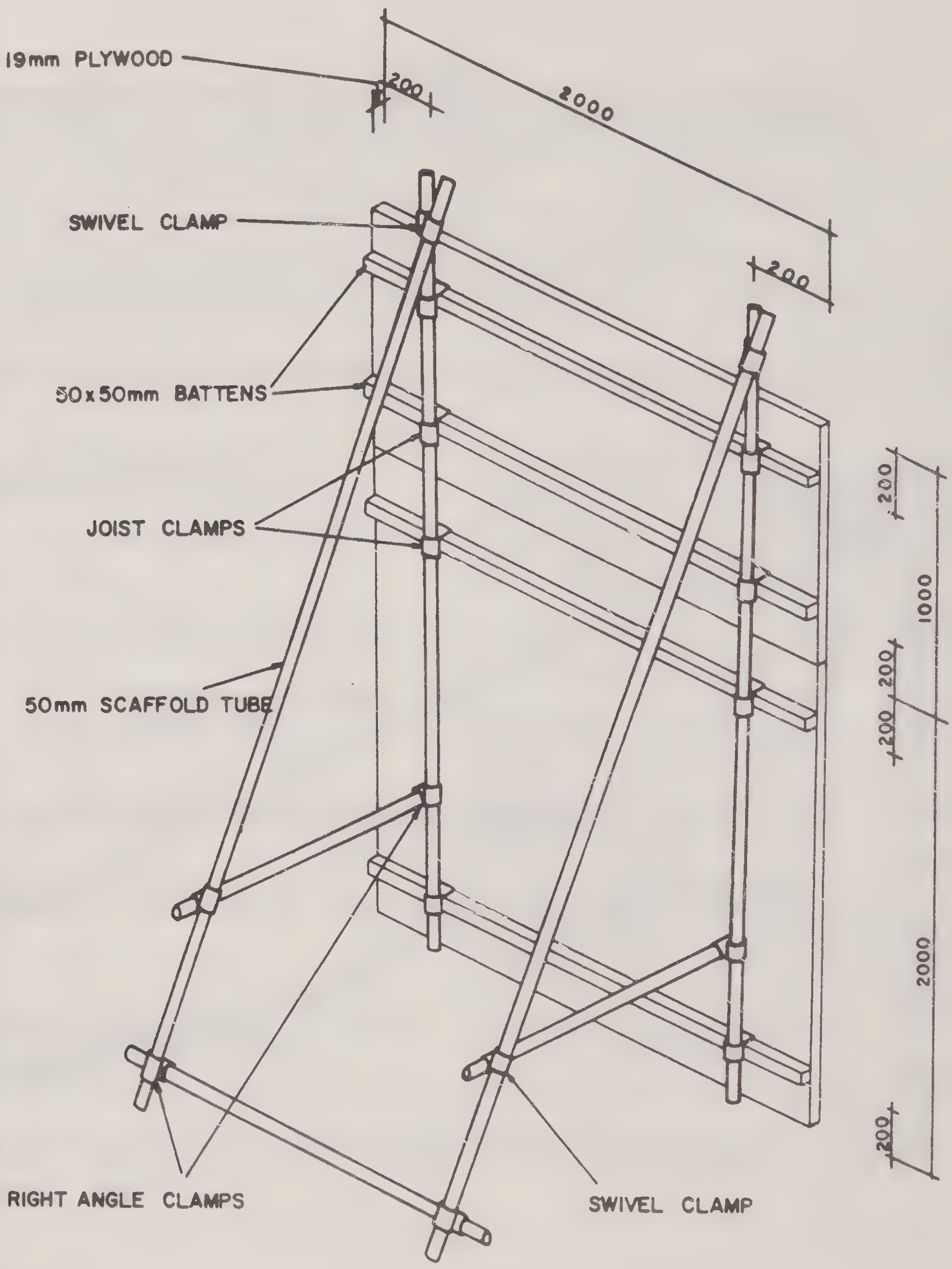


Fig 1

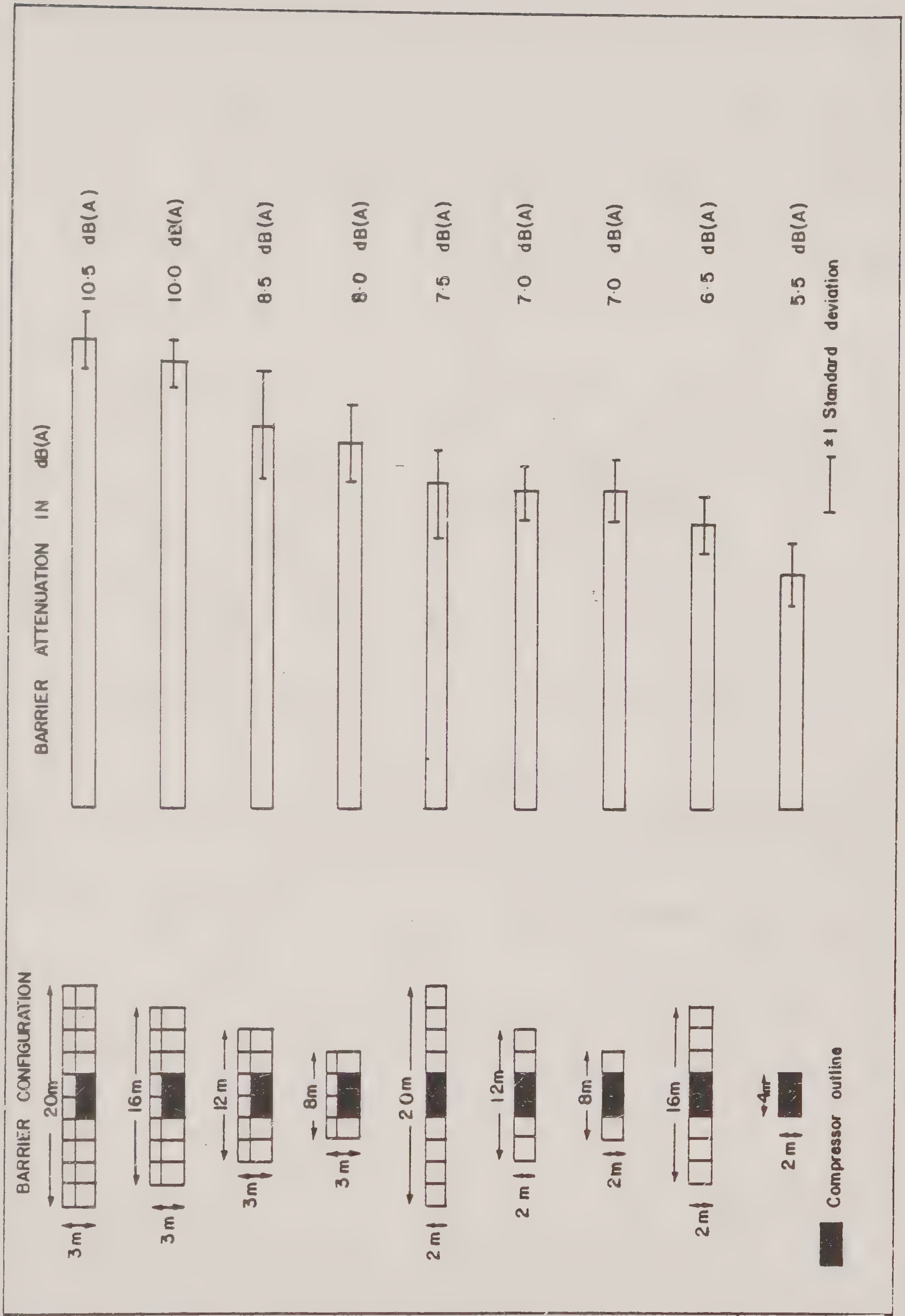


DETAILS OF A TYPICAL NOISE BARRIER SECTION

Fig 2

Wimpey Laboratories Limited

Hayes, Middlesex



DIAGRAMATIC REPRESENTATION OF AVERAGE NOISE ATTENUATION PROVIDED BY THE NOISE BARRIERS FOR DISTANCES 16m AND GREATER FROM THE SOURCE

Fig 3

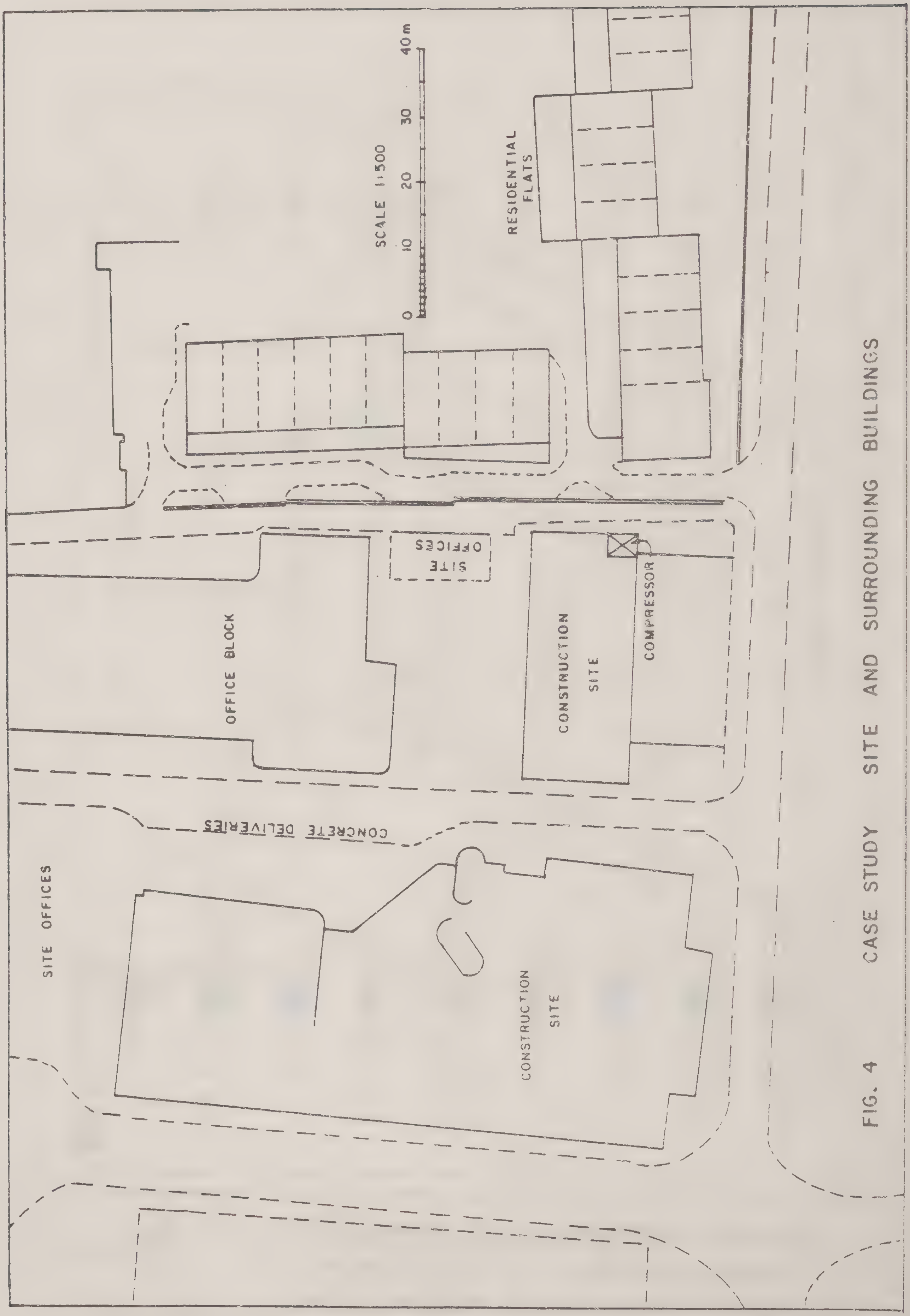


FIG. 4 CASE STUDY SITE AND SURROUNDING BUILDINGS

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AIR POLLUTION AND HEALTH – THE CHANGING SCENE

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As we approach the 30th anniversary of the disastrous London fog of December 1952, that finally, after centuries of hesitation, focussed the attention of the world on the major effects that air pollution can have on health, it is time to reflect on the successes and implications of the remedial action that followed.

Firstly, there is no doubt that the Clean Air Act has yielded outstanding benefits in terms of cleanliness of the environment and improvements in health. There is no longer any evidence of sudden increases in deaths or hospital admissions, or of exacerbations of illness among bronchitic patients, that can be associated with air pollution. There are indications too that the prevalence of bronchitis itself is declining in this country, particularly in London and in other cities that were at one time so heavily polluted.

We can perhaps count ourselves lucky that the clean air programme has gone so smoothly and relatively speedily. It was anticipated that it would take up to 30 years to eliminate coal smoke from the defined "black" areas of the country, but most of the major cities became smoke-free within 10 to 15 years. Several other factors contributed to this progress, including inner-city redevelopment in which the use of coal fires in the new multi-storey flats became impracticable, and changes in fuel prices. In particular the more competitive price of gas, especially as North Sea supplies were brought in, had a major impact on domestic heating methods and that led to an added bonus in terms of falling SO_2 as well as smoke levels.

These favourable trends have without doubt reduced the exposure of people, at least in the larger cities, to pollution derived from coal-burning but as this source of pollution has declined attention has been directed more to others, such as motor vehicles. What has to be recognised then is that relationships between environmental concentrations and human exposures can be very different in the case of "non-chimney" emissions from those that hold for pollutants emitted from domestic or industrial stacks, and it becomes much more difficult to investigate effects on health in a quantitative manner. Chimney emissions are substantially diluted before they reach ground level and with virtually every house acting as a source of smoke and/or SO_2 in the pre Clean-Air-Act days, concentrations used to be reasonably uniform over short distances within a residential area. In contrast, motor vehicles emit within the breathing zone, providing opportunities for people to be exposed at least momentarily to pollutants before dilution has proceeded to the same extent, and actual exposures depend very much on how close to traffic a person is.

We then become concerned with the "micro-environment" of the individual, rather than with the general urban pollution, and this applies not only to motor vehicle sources but to others that occur, for example in indoor environments. The disappearance of the coal fire has in fact had much to do with the mounting interest in indoor-generated pollution. While there was always the risk, particularly during calm temperature inversion conditions, of people being "fumigated" indoors occasionally with very high concentrations of smoke and SO_2 through down-draughts in chimneys, in general the coal fire was an effective ventilator, inducing something like 10 air changes an hour in a room, quickly removing any other pollutants produced within it (though at the same time bringing in the outdoor pollutants).

Now, in the absence of an open coal fire, and with our homes sealed more effectively in the interests of fuel economy, there is a far greater contrast between indoor and outdoor pollution than there used to be. On the benefit side, the major outdoor pollutant that remains, SO_2, is to a large extent shut out, for absorption on walls, furnishings and clothes removes much of that now entering, but against that cigarette smoke and emissions from unflued heating or cooking appliances build up much more readily to levels of possible concern in relation to health or general comfort. Perhaps the most universal problem is the condensation that occurs on cooler walls or windows in the house, as a result of water from cooking, washing, breathing or the combustion of fuels being removed less readily. This is certainly a major amenity problem, and it may lead indirectly (e.g. through mould growths) to adverse effects on health, but the remainder of this discussion is concerned with certain specific pollutants arising in a variety of micro-environments. Since there is overlap between some of the major pollutants emitted from motor vehicles and those arising in the home, these topics will be dealt with collectively.

Carbon monoxide. Petrol engines are regarded as notable sources, and they are certainly the main contributors to outdoor concentrations in towns. However, for reasons mentioned above, they are not necessarily the main contributors to human uptake. This gas is absorbed by the blood, having a much stronger affinity for haemoglobin than oxygen, and it can thereby reduce the oxygen-carrying capacity of the blood, with possible (short-term, normally reversible) effects on the central nervous system. Equilibrium between CO in the air and in the blood is achieved gradually, over periods of the order of a few hours, so that transient exposures to moderate concentrations, as in crossing a busy street, have little effect. More extreme circumstances, for example with prolonged exposures in traffic tunnels, where concentrations may rise to some hundreds of parts per million rather than the 10 to 20 ppm typical of busy streets, could be of more concern. The dominant source of exposure for people who smoke cigarettes regularly is, however, their own smoking: typical carboxyhaemoglobin (COHb) levels for smokers are around 3 to 4% saturation, reaching over 10% in some chain smokers during the day, compared with under 1% in non-smokers not exposed to notable environmental sources. These values are largely below the range associated with demonstrable clinical effects of carbon monoxide poisoning, though impairment of ability to perform repetitive tasks has been reported by some research groups in experimental studies at COHb values below 10%, and effects in terms of a reduction in time required for the onset of pain in exercise tolerance tests among patients with angina pectoris have been reported at values down to about 3%.

Indoor sources of CO, although small compared with motor vehicles in respect of quantity emitted, can have a relatively profound effect on uptake because of limited ventilation and long periods of exposure. Malfunction of unflued gas or kerosene heaters or cookers can lead to large and potentially dangerous concentrations, while small amounts are liable to be emitted even in normal operation, producing concentrations indoors higher than are commonly found in streets. Cigarette smoking can contribute to the CO content of the air in a room, but only in extreme circumstances, with many smokers in a poorly ventilated room, would this be substantial in comparison with other indoor sources. The more obvious effect of smoking is the irritation to the eyes or throats of non-smokers in the room, attributable to other gaseous components and to the particulate phase.

Undoubtedly the most serious risk within the home is from the accidental blockage of flues serving fixed fires or boilers. There are around 100 deaths per year attributed to this cause in England and Wales, and further deaths occur from CO poisoning through the use of cookers or heaters in confined spaces, such as boats or caravans. These problems are not necessarily confined to gas or oil appliances, but if they arose with coal the associated smoke and/or SO_2 would serve as an early warning that something was amiss. It is possible that there are many cases of people being repeatedly affected by carbon monoxide from partially blocked flues, causing ill-defined symptoms that might include reduced ability to concentrate, lassitude and headaches, but it is difficult to establish any cause and effect relationships without making measurements of the CO concentrations in the room, or in the blood or exhaled air of the individual at or very close to the time of exposure.

Oxides of nitrogen. While both petrol and diesel engines are substantial contributors to oxides of nitrogen as found in streets, there are again domestic sources (notably gas cookers) and it seems likely that in many cases human exposures are dominated by this indoor pollution component. It is the NO_2 rather than the NO that is of possible concern in relation to health, but there is no clear indication as to whether concentrations that may be encountered in homes (with peak values for NO_2 up to 1 ppm) are sufficient to produce any demonstrable effects. In studies done in this country, the occurrence of respiratory illnesses in children has been found to be somewhat higher where gas rather than electric cookers are in use, but it is not clear whether this represents a specific effect of NO_2. Smokers inhale relatively large quantities of oxides of nitrogen from their own smoking, but it is mostly as NO: there can however be appreciable production of NO_2 in indoor air from smoking.

Aldehydes. These organic compounds are emitted in many combustion processes and they contribute to the odour and irritation from motor vehicle exhausts as well as from cigarette smoke and bonfires. A relatively new source of formaldehyde is that released in some circumstances from urea-formaldehyde resins as used in chip-board furniture or in foam cavity-wall insulation. All these are truly micro-environment problems, for exposure is only appreciable close to the sources or within specific homes. The immediate effect is eye or throat irritation, and there is no evidence that exposures of the magnitude likely to occur among general populations have any long-term adverse effects.

There are many other pollutants that can be identified in motor vehicle exhausts or that may be dispersed in homes or other special environments. While few appear to pose problems in relation to the health of the general public there are occupational groups subject to relatively high exposures that require special consideration, and individuals may be exposed to potentially harmful dusts or fumes, perhaps in the course of hobbies or "do-it-yourself" activities. Control of exposure then becomes a much more personal matter than it was for the all-pervading coal smoke.

There is no doubt however that the most widely demonstrated adverse effects on health associated with a "micro-environment" pollutant are those of smoking, and the smoker himself holds the key to control.

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A REVIEW OF POLLUTION IN BUILDINGS AND UNDERGROUND FACILITIES

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INTRODUCTION

Before discussing pollution within enclosed buildings or homes it is worthwhile to consider why more attention is being given to this area. The great 'Sanitary Improvement' of Victorian times raised living standards and expectation of life. In turn, that improvement showed up the industrial accidents and mortality of those times, which were then gradually improved. Rising standards and expectations of environmental quality led to the formation of this Society, amongst others, the NSCA concentrating on air pollution control. The transformation of air pollution from a gross offence to humanity to a subtle, less serious but insidious problem is a mark of this Society's success. As a child raised in central London, with personal experience of the London Smog Disaster of 1952, I find the transformation of London in winter to be dramatic. The pattern, therefore, is one of advances in one field, exposing a pollution/environmental health problem in another field. Dealing with the problem now exposed will reveal another, and so on.

It is worth acknowledging that this progression has led to successively higher levels of environmental quality. The air in the interior of a gas heated council house would be sweet to a Victorian slum dweller in a pea soup smog. The point is that the expectations of life are very different in the 2 situations. The problem lies in deciding if the effects reported are significant in our current and near-future context, not if they are significant in some past context idealised as a soft focus, soft colour 'Hovis Land'!

One further point concerns the way in which we have approached past problems. Problems are first identified, their causes established and solutions sought. Solutions frequently involve better combustion, a change to a better fuel, and trial and error has led to legislation and enforcement. I will be looking at enclosed/indoor pollution in the order of at least the first 3 set out above.

The problem divides on several counts into enclosed public buildings and homes and I will deal with the enclosed situation first.

ENCLOSED BUILDINGS

Reviewing the literature is a difficult process as it tends to be dispersed over a very wide range of publications. Nevertheless, it is clear that most enclosed/partially enclosed building pollution problems are closely associated with running internal combustion engines inside these buildings. It is not sufficiently realised that the petrol/LPG spark ignition engine is inherently polluting for successful operation.

The combustion products diagram in Figure 1 shows how the exhaust composition is critically dependent upon the air/fuel ratio. The 'ideal' air/fuel ratio is at about 15:1 but the engine then runs erratically, hot and unreliably. Most engines run at an exhaust composition of 3% carbon monoxide, for a warm engine, ie. excess fuel or 'rich'. Engine manufacturers are slowly edging towards the excess air or 'lean' side of the equivalence point, amongst others, utilising the 'fast lean burn concept'. Modern engines are far less polluting than their forebears, eg. the Ford Model 'T' reputedly had an exhaust composition of 12-15% carbon monoxide. On the other hand, it produced very little nitrogen oxides, NO_x!

Multistorey car parks are the classic case of engines being run within an enclosed/partially enclosed building. The pollution problem starts with those vehicles leaving the car park, or trying to do so. The engine is cold and thus the choke is operated. Some Americans eloquently call the choke mechanism the 'air strangler' - it sends the mixture rich, ie. low air/fuel ratio and thus high carbon monoxide. That is the source, which would be rapidly removed as the vehicle leaves the car park. Many times, however, the vehicle is caught in an internal traffic jam caused by various factors.

Ivor Barker and I have studied many car parks(1) under many conditions of use. There is no doubt that most car parks are well sited, well-managed and do not have exit traffic congestion. However, some car parks cannot respond to a sudden surge of traffic wanting to leave or are prone to the exits being blocked by city centre congestion. The longest time confirmed for exit from a car park is 105 minutes in the centre of a very large West Midlands city in the late afternoon of Christmas Eve, the problem being city centre congestion allowing only a very slow rate of vehicular exit. Another case was 75 minutes for the exit time of a car from the car park of a large entertainment complex in North West London.

Often when people wish to leave a car park the surrounding road system is saturated or the sudden rush of vehicles is far in excess of the rate at which their parking tickets can be processed. The throughput of vehicles is also less than optimum because of markedly reduced driving ability in closely contained surroundings with very subdued lighting.

For a jammed car park, with car engines running with chokes operating, the rate of ventilation is important. There is little problem with 'high rise' car parks of open design, certainly none at all for the upper storeys. If the bottom storeys are submerged in a shopping development, then these will be polluted down to the pay-kiosk but the residence time of the car is short in this section. Overall, carbon monoxide is rapidly dispersed or passenger exposure is short. The dispersion here is either natural or readily assisted by the prevailing wind. However, car park design is not an advanced art and generally takes second place to the dictates of an associated shopping precinct. One instance is where the car park is on the 2 top levels of a city centre 'development'. The first layer has poor ventilation, being only 2.4 m high, with maximum horizontal dimensions of 130 m x 130 m. The air flow is reduced by various dividing walls, plant rooms, the glazed roof of the shopping wall below and various contiguous buildings. The top deck of the car park was completely open. As a simple test of the ventilation rate we measured the wind speed on the 2 levels. The maximum ratio was 1:3 for wind speeds on the upper and lower levels, strongly dependent on the relation of wind direction to the layout of the surrounding buildings. Figure 2 shows the concentrations of carbon monoxide against time for a Saturday and for a Tuesday, the first demonstrating the effect of shopping congestion.

Many of these points seem obvious. Another car park investigated lies underneath a very popular and successful shopping development. It is artificially ventilated and the times of peak use are well known. The management opens another, temporary, kiosk in addition to the 2 normally operating, the traffic flow is strongly and positively managed and the net result is maximum flow without confusion, into a quiet street. Given the potential for carbon monoxide pollution the levels are quite low at 40-50 ppm, with a maximum waiting time of 5 minutes. But due to the varying levels of the site, at one end the underground car park forms the lowest level of a 4 storey car park exiting into a main shopping street. Only one edge of this car park is open to air. Vehicles wend their way up through the various levels and approach the pay kiosk situated at the end of a long steep slope. Most customers are unused to hill starts in this situation, with much over-revving of engines and slow progress at peak times, up to 30 minutes, in an atmosphere of 400-450 ppm carbon monoxide.

The final slope had values of 170-200 ppm with values of 200-700 ppm close to the kiosk. For the times of exposure noted, the values of carbon monoxide are too high for industrial workers, and far too high for general population exposure.

Car parks are designed more to comply with the Fire Regulations than with ventilation requirements. Forced ventilation is expensive to install and operate and increases the vertical deck spacing. Signs can be installed, linked to continuous carbon monoxide sensors, but they tend to be ignored.

The problems of a car park can be made much worse by subsequent development of contiguous buildings or altered traffic schemes affecting the exit conditions. One car park had no recorded problems of pollution until 3 office blocks were built extremely close to it, effectively blocking through ventilation. Clearly, the effect of the office developments on the car park development was not considered. The investigators of this car park problem suffered nausea and physical sickness from the carbon monoxide. The effect of carbon monoxide on a fit adult undertaking light exercise is given in Figure 3. The graph is slightly complex, the product concentration of carbon monoxide and haemoglobin, carboxyhaemoglobin (COHb) varying with carbon monoxide composition breathed in and the time of exposure. Carbon monoxide competes with oxygen for haemoglobin, (2,3) as;

$$CO + Hb \underset{}{\overset{K_1}{\rightleftharpoons}} COHb \qquad \text{Carboxyhaemoglobin}$$

$$O_2 + Hb \underset{}{\overset{K_2}{\rightleftharpoons}} O_2Hb \qquad \text{Oxyhaemoglobin}$$

where the ratio of K_1/K_2 is of the order of 275. The effects of carbon monoxide manifest themselves as;

i) Headache, with reduced mental activity
ii) Throbbing headache
iii) Vomiting and collapse
iv) Coma
v) Death

Kiosk attendants in some car parks are exposed to carbon monoxide levels well above Threshold Limiting Values, particularly when the (often) extended shift working hours are taken into account, 12+ hours being common.

This effect is also reported by Bouteiller et al.(4) The hourly variations of carbon monoxide and lead for a kiosk are shown in Figure 4. The values for lead are quite close to those found for tollbooths on the Massachusetts turnpike by Burgess et al(5) whilst the carbon monoxide levels are lower for the more open tollbooths.

Whilst the effects on health of carbon monoxide exposure have been examined in depth for both fit persons and people suffering from conditions likely to be exacerbated by COHb in blood, the effects of carbon monoxide on 'performance' are much less well defined. Tests on drivers of cars driven around heavily trafficked roads in and around London showed 12–60 ppm carbon monoxide, relating to between 30 and 80% of outside concentrations. Carboxyhaemoglobin concentrations in the drivers blood ranged between 1.5 and 3%. Whilst this is judged not to produce an adverse effect on health, it is not clear as to whether driving performance would be impaired.(6) The main problem lies with determining a satisfactory definition of driver performance and a measure of its deterioration.

Given a balanced, analytical and responsive approach I believe that almost all pollution problems within multi-storey car parks can be successfully resolved. Certainly, with the worst car park example that I have experienced so far, the thin sandwich on top of a shopping development, the City Engineer's Department went to great lengths to make subtle traffic management alterations so as to maximise the chances of vehicles leaving the car park. A pedestrian-controlled crossing has been moved upstream of the exit and a downstream roundabout substantially altered and another crossing moved. If the confused traffic pattern within the car park was rationalised, then further improvements would result.

A distinction is made between carbon monoxide as a general pollutant which can have immediate effect and lead, which requires more continuous exposure and, whilst important as an industrial hygiene problem, is outside the range of this review.

Other areas where carbon monoxide in enclosed space is a hazard include ice rinks and mobile cleaning vehicles. It is often assumed that because such machines as ice polishers and small cleaning vehicles are powered by LPG (liquid petroleum gas) the exhaust is 'clean'. This might be the case but very often these machines are sadly out of adjustment and very high carbon monoxide levels are reported, such as 304 ppm in an ice skating rink after surface polishing(8a) and more recently 57 ppm.(8b) These values can be corrected by improving the ventilation system.

Trace minor irritants are also found at low concentrations such as indans, tetralins and unsaturated carbonyl compounds from filters set up in car parks. No guidelines, including TLVs, exist for these compounds, which are noxious and irritating at low concentrations. Diesel vehicles emit their characteristic odour which is both stronger and more disagreeable than spark ignition engines. Quantitative measurement is extremely difficult, even by GC-MS methods and 'nose panels' are the best method of assessing odour problems. A typical diesel exhaust may contain up to 1,000 identifiable compounds of which 100 are odourants.(10) Run on pure hexadecane, up to 75 compounds can be identified.(11) These problems will increase as the predicted increase in diesel penetration of the motive power market takes place.

INDOOR AIR POLLUTION

Homes have been polluted ever since fire was used indoors. In relatively primitive society living conditions which can be measured at this time, high concentrations of carbon monoxide and benz-α-pyrene have been measured in rooms heated by open burning of wood or charcoal for cooking or heating with poor ventilation. Benz-α-pyrene levels of 166 ng/m^3 have been found in native huts of mountainous Kenya - in comparison, New York City air contains 1-5 ng/m^3 (in 1980).(12)

The problem of indoor air pollution has become more important with the strong, positive trend towards energy conservation. The most cost-effective measure in domestic energy conservation is draughtproofing - which thereby reduces ventilation. A notable exception from Table 1 is sulphur dioxide, which is adsorbed onto internal fabrics and decoration, including wallpaper. The overall effect is for internal sulphur dioxide concentrations to be less than outdoor values at the same time.(13)

Table 1

Pollutant	Source	Potential Health Effects
Asbestos	Building Materials	Mesothelioma, Asbestosis
Formaldehyde	Building Insulating Materials	Irritation of Eyes and Respiratory Tract
Radon	Ceramic Building Materials	Cancer
Nitrogen oxides ($NO/NO_2 = NO_x$)	Gas Appliances Oil Fires Tobacco Smoke	Respiratory Illness
Suspended Particulates	Coal Fires Tobacco Smoke	Respiratory Illness
Carbon Monoxide	Gas Appliances Tobacco Smoke	Hypoxia

There are 2 points here - the enhanced adsorption indoors and that there are no important sources of sulphur dioxide emissions occurring indoors (except for a poorly flued high sulphur coal fire). It has now been convincingly demonstrated that higher concentrations of pollutants (other than sulphur dioxide) can occur indoors than that outdoors.(14, 15) Whereas now it is quite difficult to associate respiratory disease with the drastically reduced atmospheric sulphur dioxide and particulate levels by epidemiological methods, it is possible that effects from indoor pollutants may now be revealed. Looking at the components of Table 1 in turn:-

PARTICULATES

Cigarette smoking is a prime cause of particulate, as well as nitrogen oxides, carbon monoxide and odour. In smoking-allowed bars and restaurants the respirable content of particulates was as high as 589 ng/m^3 compared with a maximum of 55 ng/m^3 in no-smoking areas.(16) it has been calculated that 10 air changes per hour are necessary to reduce the respirable particulates to ambient levels, which would be draughty and wasteful of energy. Most heating and ventilation designs assume one air change per hour.

Cooking may increase respirable particulates to even higher levels. What is not established is whether the composition of the enhanced respirable particulates is a hazard, separate from the other pollutant products of cooking. There is a tendency to assume that indoor respirable particulate is the same as outdoor particulate. It may be worse, as for cigarette smoke particulate, or not as hazardous, as for cooking.

NITROGEN OXIDES

The conventional wisdom is to only consider the oxygen component of air as active in combustion equations, adding in the nitrogen for mass or volume flow calculations. Premium fuels such as natural gas, (methane) and propane burned at atmospheric pressure have a very high combustion flame temperature such that the atmospheric nitrogen begins to react, giving $NO_x(NO+NO_2)$. A National Survey of Air Pollution study established a relationship between respiratory illness of children and the use of gas cooking in the home, in 1973 and in 1977, which was independent of age, social class, the number of smokers in the house and latitude of the area but it was only significant in the urban areas.(17)

Nitrogen oxides, as NO_2, were suspected as the cause of the association, from un-flued gas cookers. Reasonably accurate measurement of NO_2 levels in many homes is a formidable sampling and analytical problem. This was overcome by using a small plastic tube sample containing absorbent specific to NO_2. The collection is diffusion controlled and requires no external power. Comparison with the fearsomely complex and expensive chemiluminescent method showed an accuracy better than 110%.

The Cleveland Respiratory Study was an example of meaningful co-operation between St. Thomas' Hospital Medical School, Department of Community Medicine, Middlesborough Borough Council, the Local Education Authority and the Area Health Authority. Details are given in the excellent set of papers published by Melia et al.(17, 18) The results are not straightforward. Whereas the risk for young primary school children of respiratory conditions was higher in homes with a gas cooker than homes with an electric cooker, the risk was independent of age, sex, social class and smoking in the home. No relationship was found between the frequency of respiratory conditions and kitchen NO_2 levels, or between lung function and either kitchen or bedroom NO_2 levels. The most important association was that within gas cooking homes the frequency of respiratory conditions was higher in homes with high levels of bedroom NO_2 than homes with low levels. Parental respiratory illness is unaffected by the cooking fuel or levels of NO_2.

In its context the Cleveland Respiratory Study confirmed the relationship between gas cooking and respiratory illness in children found for 2 different, previous groups of children in the United Kingdom. The relationship is subtle and it is not surprising that a different approach finds different emphases. Thus, no association between gas cooking and respiratory illness in children has been found by Lutz et al(18) and US-EPA(19) study - on the other hand, Speizer et al(20) found a relationship between gas cooking and a history of respiratory illness before the age of 2 and poor lung function. Further work is being undertaken on related effects of humidity (associated with humidity), possible ventilation changes and low temperatures. The fact that respiratory illness is only significantly associated with high NO_2 bedroom levels (40-169 ppm range) might well be associated with a lack of ventilation. Melia et al point out that if pollution from gas combustion is indeed harmful to health then it might be simply dispelled by improving kitchen ventilation - an opening window, an air vent, cooker hood or even a flue.

CARBON MONOXIDE

Carbon monoxide has traditionally been closely controlled to very low levels in the home where gas is used as a fuel. Where high levels occur, the carbon monoxide results from an accidently blocked flue or a profound lack of maintenance.

The main source of carbon monoxide in homes, other than from the above, is smoking. Bridge et al(21) measured average carbon monoxide concentrations of 9 ppm at a party where 50 cigarettes and 17 cigars were consumed in 90 minutes. Public areas have been reported as having 25 ppm carbon monoxide for 8 hours with inadequate ventilation and no control of smoking.(22) These values are at and then well above, respectively, the US Air Quality Standards.

The effect of high indoor carbon monoxide levels under inadequate ventilation can particularly affect unborn children. Foetal carboxyhaemoglobin (COHb) is normally 20-30% of that for adults and Longo(23) has shown that significant increases in maternal and foetal COHb concentrations, as in mothers who either smoke directly or 'passively' smoke a carbon monoxide atmosphere, can severely reduce oxygen delivery to foetal tissues. It is well known that smoking mothers have smaller babies, a higher incidence of still births etc. and appear to be dose related.(23) The smoking household 'seems to affect the growth of children' (Brit. Med. Jnl., 283, 1363, 1980).

RADON, FORMALDEHYDE AND ASBESTOS

These are grouped together as building/furniture material emissions. Many people were, no doubt, surprised by radon's presence in the home from building products. The gas, radon, will decay by a radioactive process to give 4 possible elements which are solid and radioactive. These can become attached to the lung and cause cancer in the longer term. The emissions vary from one area of a country to another, dependent upon the source of the building materials and the concentration of radium, the source of radon, at very low levels in the material. Detailed study is underway in this country from the National Radiological Protection Board. The overall picture, from American and Swedish results, seems to suggest that as radon is a gas, then ventilation should be adequate to keep its standing concentration at a low level.

Formaldehyde can occur from ill-mixed foam insulation products. More concern has been expressed in other countries; where the inner leaf of a house wall is generally much more porous and poorly made, foam can emit formaldehyde into the home. Where foam has not been been prepared properly, formaldehyde respiratory and membrane irritation has been obtained in this country following cavity insulation work. Some furniture materials can outgas formaldehyde as well. Fluorescent lights, in offices or homes, give significant near-ultra violet light which can initiate a photochemical reaction of formaldehyde with other materials – indoor photochemical smog. Sterling$^{(24)}$ has reported such an incident in an office block in Vancouver, giving rise to headaches, nausea, eye irritation and drowsiness. The remedy was better ventilation and different bulbs.

CONCLUSION

A common thread running through the examples given here is the need for better ventilation of underground or partially enclosed public facilities and in the home. Air pollution of these areas can be measured and can be worse than the external air. The effects induced by this indoor pollution are now being measured and shown to be significant. However, the current trend on the energy conservation drive is to lower ventilation rates. Whilst energy conservation is inherently as well as 'felt' to be 'a good thing', our enthusiasm for it should be tempered by realising that there are lower limits to ventilation rates. Those lower limits should be set bearing in mind both the energy required to heat the make-up air and the indoor air quality standards necessary to, as one instance, reduce school children respiratory illness to the norm in council house tenancies cooking by gas. Let us not be so enthusiastic to deal with the energy problem such that we create or exacerbate another, indoor pollution problem.

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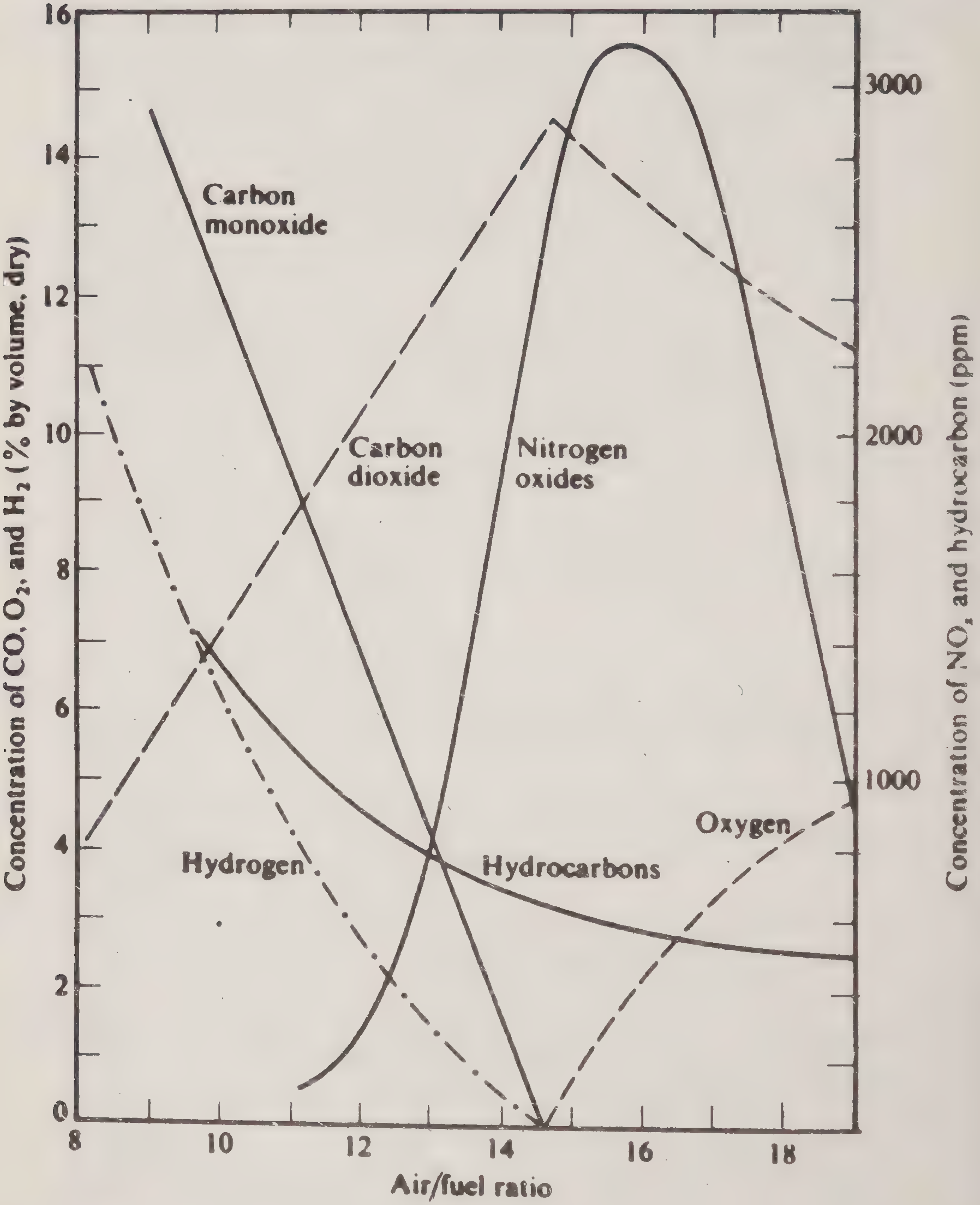

Figure 1

Individual component concentrations in petrol engine exhaust as a function of air/fuel ratio.

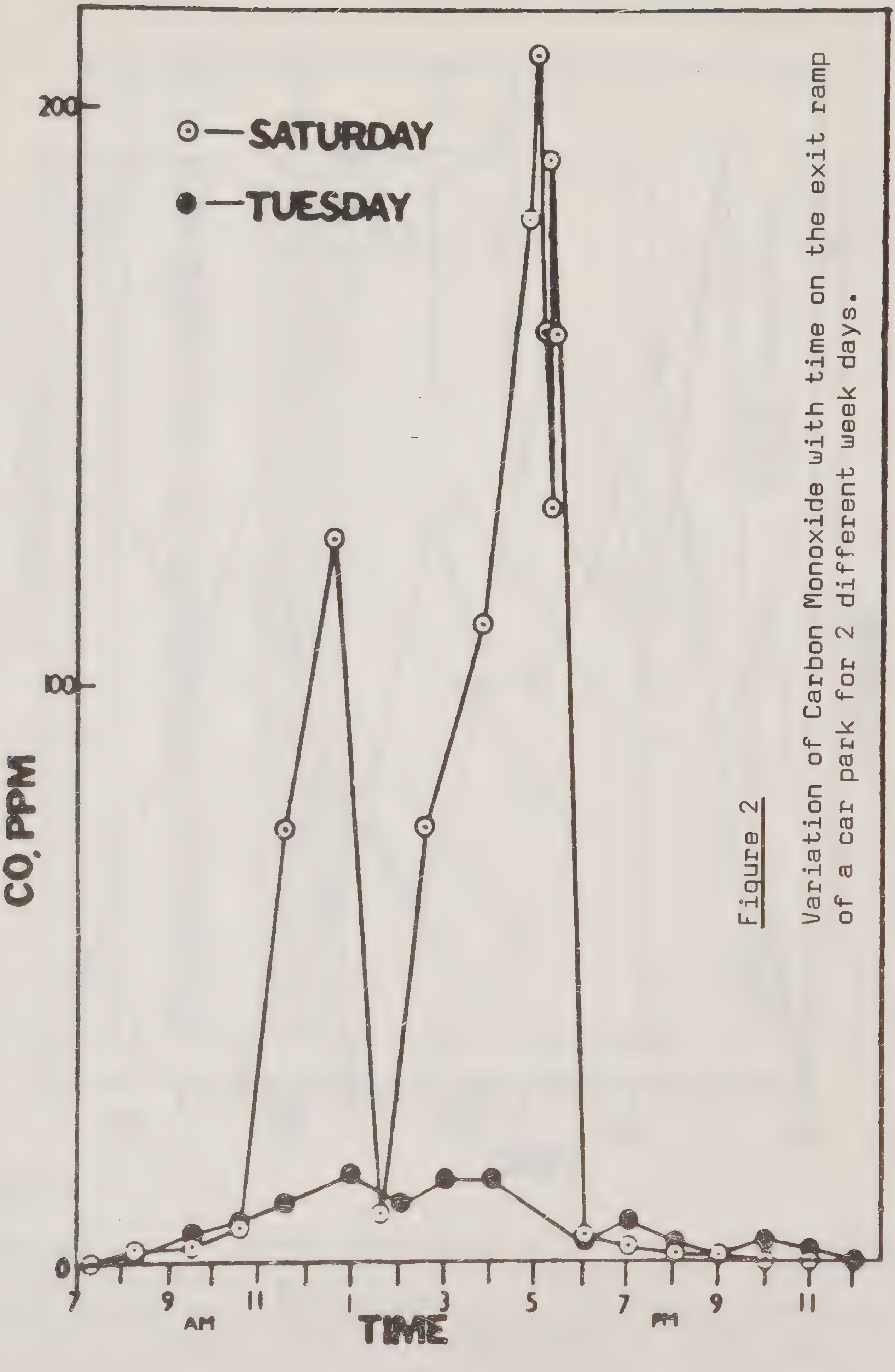

Figure 2

Variation of Carbon Monoxide with time on the exit ramp of a car park for 2 different week days.

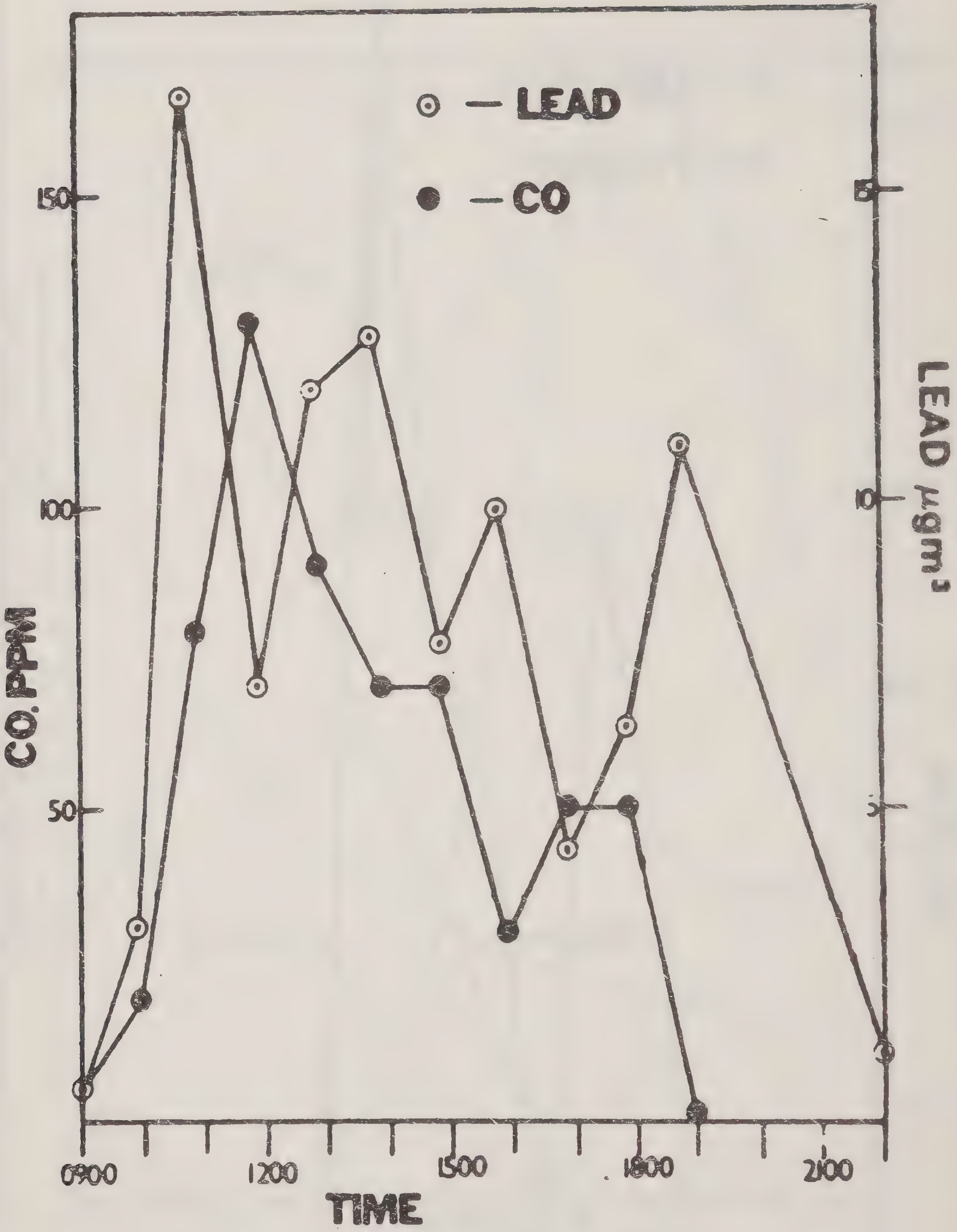

Figure 3

Hourly variations of Carbon Monoxide (●) and Lead (⊙) in the pay kiosk of a car park.

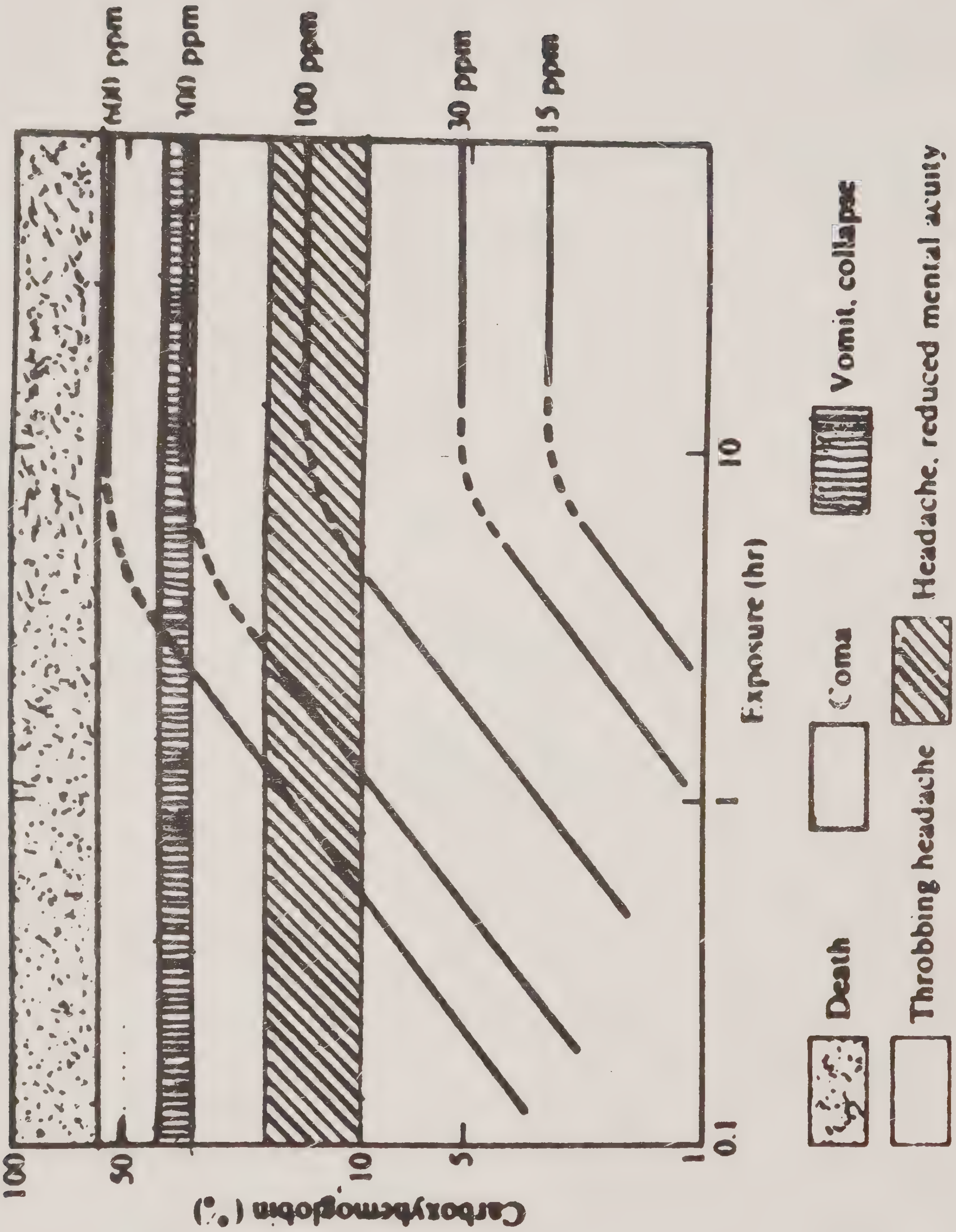

Figure 4

The effects of Carbon Monoxide on a fit adult undertaking light exercise, as a function of time exposure, Carbon Monoxide concentration and Carboxyhaemoglobin concentration. (Note - axes are log scales!)

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THE FINDINGS OF THE EC BLOOD LEAD SURVEY

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INTRODUCTION

In the mid 1970s there was growing concern about lead pollution in the environment. At that time, most of the investigations of lead levels in humans had been on a small scale and indicated widely differing levels in different sountries, or were clinical studies - mostly of children and often of those suffering from lead poisoning or very high exposure. Accordingly, in 1977 the Member States of the EEC agreed to carry out a screening programme aimed at adults in inner and outer urban areas and groups exposed to a significant source of lead pollution. The results from each survey were to be compared with certain reference levels, which were based on the information then available. Stringent national and international quality assurance schemes were set up and strict criteria were applied to ensure the accuracy and consistency of the laboratories' blood lead analyses.

After discussing the details of the EEC Directive on the surveys, and the organisation of the surveys in the UK, this paper looks at the results in relation to the EEC reference levels. The surveys have provided a very large amount of bench mark data on blood lead distributions in the groups of people studied. The effects of various personal factors such as age, sex, social class, ethnic origin and smoking and drinking habits are examined, as well as environmental factors such as older housing, water which dissolves lead from pipes, major roads, and the exposure of children to leadworks. In addition, some broad comparisons have been made of blood lead concentrations in the nine EEC countries.

EEC DIRECTIVE AND REFERENCE LEVELS

In 1977, the European Economic Community Directive 77/312/EEC[1] on the biological screening of the population for lead, was formally agreed by all the nine Member States. The Directive specified that there should be two campaigns, separated by two years; the surveys actually took place in 1979 and 1981. All participants in the surveys were to be volunteers, and overall there were to be at least 50 participants per million inhabitants: this implies a minimum of about 20 in Luxembourg and about 3,000 in France, Germany, Italy and the UK. There would be three recognised categories of sample: randomly selected adults in major urban areas; people exposed to a significant environmental source of lead such as lead smelting works or battery factories; and critical groups at special risk. Those exposed to lead in the course of their work, for example employees in lead smelters, were to be excluded. But a few people who were exposed to lead in a minor way, for example plumbers and garage mechanics, were included in the surveys.

The results from each sample were to be compared with certain reference levels. These specified that for each sample,

no more than 50% should be above 20 µg of lead per 100ml of blood;

no more than 10% should be above 30 µg of lead per 100ml of blood; and

no more than 2% should be above 35 µg of lead per 100ml of blood.

For comparison, blood lead levels in Scandinavia average about 5 µg/100ml, while those in the general population in the UK average 10 to 15 µg/100ml; clinical symptoms of lead poisoning appear at around 80 µg/100ml.

The EEC Commission was to be notified if these reference levels were exceeded, and action had to be taken to trace and reduce the source of exposure. Follow-up investigations were to take place if any individual had a blood lead concentration greater than 35 µg/100ml. As an extra safeguard, in the UK this was done for any child with a blood lead concentration greater than 30 µg/100ml.

THE ORGANISATION OF THE SURVEYS IN THE UK

Overall responsibility for implementing the EEC Directive rested with the Department of the Environment, but a Steering Group including representatives from other Government departments co-ordinated the surveys. The autonomous local surveys were carried out by the local authority with advice from its Medical Officer of Environmental Health, or by the Area Health Authority. Since levels of lead in blood show a seasonal variation, the blood sampling was carried out over a relatively short period of time in the spring of 1979 and 1981 in order to minimise this effect.

1979 Campaign[2]

In the first campaign in 1979, there were 30 surveys in the UK (Figure 1) in which nearly five thousand blood samples were collected. Two thousand randomly selected adults took part in surveys in the inner and outer areas of Birmingham, Leeds, Liverpool, London, Manchester and Sheffield; there was one city wide survey in Glasgow. Two thousand children, either children of leadworkers or living near a leadworks, were sampled in nine locations. including Ellesmere Port, Gravesham and Market Harborough. Three hundred adults and five hundred children living near major roads were sampled in London and Leeds. In Glasgow, in addition to the random surveys of adults, blood lead concentrations of mothers and their three month old infants were measured as part of a study of dietary intakes of lead. The infants formed the only UK group in the category "critical groups at special risk".

It should be emphasised that although there were random surveys of adults in large urban areas, there were no similar random surveys of children. This was because local ethical committees were extremely reluctant to give the necessary permission for blood to be taken from children unless there was a clear indication that the health of the children was at risk. The BMA has recently issued even stricter guidelines on this.

1981 Campaign

In the second campaign, in 1981, there were 35 surveys (Figure 2) in which nearly four thousand people took part. As the results of the 1979 surveys had shown that the blood lead concentrations in the random surveys of adults were generally well below the EEC reference levels, the emphasis was placed upon specific sources of exposure, and groups were selected who were either living in predominantly older housing, or near major roads. About seventeen hundred adults were sampled in the same major cities as before, plus Bristol. The surveys of children exposed to leadworks were repeated, except at Beverley, Dartford and Newport where it was generally agreed that the position was satisfactory. In addition, there was a survey of mothers with young children at Ayr in Scotland where the water was known to dissolve lead from pipes, and a survey of Bangladeshi infants in the London borough of Tower Hamlets.

Participants

All the participants in the surveys of adults were, of course, volunteers. At leadworks, all employees were contacted, and those with children under 12 years of age were asked to give permission for their children to be included in the survey; response in these surveys was always very high: 90 to 95 per cent. Children living near leadworks were mostly contacted through school records; response rates were usually quite high: 75 to 90 per cent.

For the surveys of adults, to ensure that the sample would be representative, it was important that those invited to take part should be randomly selected. In all surveys, the electoral register was used as a sampling frame. Response rates varied from 80 down to 25 per cent, depending upon the area and on the contact method and the amount of follow-up by the local authority. In order to assess whether or not the random survey of adults were in fact representative, the sex ratio and the distribution of the age of the dwellings in the surveys were checked against the National Dwelling and Housing Survey[3] which had been carried out in 1978. The youngest age group, those under 29, appeared to be slightly under-represented, even allowing for the effect of the age qualification for voters. But adult respondents did not differ significantly from the general population in any of the characteristics which were measured in the surveys and which proved to be significantly related to blood lead concentration.

Questionaires

Figure 3 shows page 2 of the standard questionnaire which was completed throughout the EEC for each participant in the 1979 surveys. The first page contained personal information so that respondents could be identified and contacted if they were found to have a high blood lead concentration. To preserve confidentiality, this section was retained by the doctor in charge of each survey. Only the coded data were sent to the Department of the Environment. No names or addresses were passed to central government, or to the European Commission.

For the 1981 surveys, the UK form was modified (Figure 4). Questions were added on social class and ethnic origin - characteristics of respondents which might influence blood lead concentrations, but which were not included on the 1979 form. A slightly less detailed version of the form was used for children.

Blood Sampling

In all of the adult surveys except Hillingdon, and in the majority of surveys of children, blood samples were taken by venepuncture: that is, blood was taken from a vein with a syringe. In Hillingdon and in some of the surveys of children, blood was collected by the capillary method: this is done by making a scratch in the skin - usually in a finger, or for infants in the heel. Great care is needed in the collection of capillary blood samples if contamination problems are to be avoided.

Blood samples were analysed by laboratories within the Supra-Regional Assay Service. Stringent national and international quality assurance schemes were set up and strict criteria were applied to ensure the accuracy and consistency of the results.

BREACHES OF THE EEC REFERENCE LEVELS

1979 Surveys

In 1979, 33 of the 39 groups studied met all three reference levels, generally by comfortable margins. All groups sampled in 1979 met the 20 μg/100ml reference level. The surveys which breached the reference levels are given in Figure 5. Only the group of infants in Glasgow breached the second reference level of 30 μg/100ml. Six groups exceeded the upper reference level of 35 μg/100ml, including all three surveys in Glasgow.

In Glasgow, 4 per cent of the random sample of adults, and 5 per cent of the mothers and 11 per cent of the infants in the dietary study, had blood lead concentrations over 35 μg/100ml. Much of the water supply in Glasgow dissolved lead from pipes. Many of the older dwellings have lead pipes and some tenement blocks have communal water tanks lined with lead sheeting. Since 1978, the water authority has been lime dosing the water wupply. When the results of the 1979 survey became known, the lime dosing was enchanced and substantial reductions of lead concentrations in water have been achieved. It must be mentioned that the mothers chosen for the diet study were not a random sample: the sample was stratified so that those with higher concentrations of lead in their drinking water were over-represented. This was done, deliberately, to obtain a good estimate of the relationship between blood lead and water lead. When those with high blood leads were recontacted, it was discovered that a small number of mothers were using the hot tap when filling kettles. Both they and their infants invariably had very high blood lead concentrations. (A report on the Glasgow Duplicate Diet Study, Pollution Report Number 11, has been published by the Department of the Environment[4].)

At Chester, lead dust from the processing works was identified as the principal source of exposure. The company invested a substantial amount on further pollution controls, with particular emphasis on dust. In fact, the owners have recently announced that for independent, commercial, reasons the works will close later this year. The breach of the upper reference level by leadworkers' children at the Thorpe leadworks in Leeds, was most likely due to the insufficient use of washing facilities by workers preparing to go home. The survey of children living near the works met the reference levels.

In the 1979 surveys, 23 adults and 34 children were over 35 µg/100ml. All have received appropriate medical attention and advice.

1981 Surveys

In 1981, three of the 35 surveys did not meet the EEC reference levels; they are also given in Figure 5.

The group of mothers of young children in Ayr, exposed to high levels of lead in water, was the only survey in the whole of the UK campaigns which breached all 3 reference levels. Individuals with high blood lead concentrations were recontacted and given medical advice. A lead-free supply of drinking water was provided for young children. As soon as the extent of the problem of the interaction of plumbosolvent water and lead plumbing was known, remedial action was taken by the water authority. The pH of the water supply has been increased. Similar measures taken in Glasgow substantially reduced the levels of lead in water and blood lead concentrations[5].

The survey of randomly selected adults living near the Archway Road in Islington was generally satisfactory, with proportions below the lower two reference levels fairly typical of inner urban areas. But three men exceeded the 35 µg/100ml level. On investigation it was found that two had recently been renovating their houses, including stripping old high lead paint; the third had recently done casual work in the scrap metal trade, including the burning of old cables containing lead. In Gravesham, one leadworker's child out of 43 had a high blood lead. The general distribution was, however, lower than is typical for such groups, with 90% below 20 µg/100ml.

Apart from the mothers in the special dietary study in Glasgow (but including the infants), all groups where breaches of the reference levels were found in the 1979 campaign were sampled again in 1981. All met the reference levels. Improved control measures at the leadworks in Chester and Leeds, and the success of enhanced lime dosing of water supplied in Glasgow in reducing its plumbosolvency, have had a substantial effect in reducing exposure to environmental lead.

DETAILED RESULTS OF THE UK SURVEYS

Frequency Distributions

The frequency distributions of blood lead concentrations were skewed; this is illustrated in Figure 6 which shows the results for adults in inner Manchester. As with many other biological quantities, blood lead has a lower limit of zero - although in practice few are below 5 µg/100ml - but it is possible to obtain high values far in excess of the usual range. The distributions were approximately log normal; for this reason, geometric means have been used in comparisons of surveys.

Inner and Outer Urban Areas

Average blood lead concentrations were higher in inner urban areas than in outer urban areas (Figure 7); and were higher in northern cities than in London. The higher average concentrations in the north may reflect increased exposure to environmental lead, rather than social factors such as diet. As airborne lead levels in London are similar to those in other cities, the most likely source is lead in drinking water. In each city, average blood lead concentrations were higher for the inner area; but the outer Manchester levels were higher than in the inner areas of all the other cities.

Age and Sex

It must be remembered that the blood lead concentrations of the children included in the EEC surveys will almost certainly be higher than levels in the general population, because all the children were exposed to a significant (but localised) source of lead - mostly lead using works. However, the relationship between blood lead concentration and age in children, allowing for age of dwelling, etc., was similar to that found in other studies[6,7]: blood lead levels rose to a peak at age 2 to 3, fell until about 7, and then remained fairly constant up to 12 years of age (Figure 8). There were only very small differences between the blood lead levels of boys and girls up to 12 years of age.

For adults, there was no evidence that blood lead concentrations increased with age in either men or women (Figure 9). However, men consistently had higher blood lead concentrations than women: the average difference, up to the age of 65, was 3 to 4 μg/100ml. Although it may appear that average blood lead levels for men and women aged 65 to 70 were roughly equal, the results for those aged over 65 are less reliable, being based on smaller numbers of participants. Overall, there were about twice as many men than women with blood lead concentrations over 15 µg/100ml. Furthermore, of the total of 16 adults in these surveys with blood lead concentrations over 35 µg/100ml, 15 were men.

Social Class

In the 1981 surveys, a question on the occupation of the head of household was added to the form. Becauses of the small numbers of participants in social classes I and V, the results for social classes I and II have been grouped together, as have social classes IV and V. Somewhat surprisingly, there were no clear differences in blood lead concentrations in males among the social classes (Figure 10). The distributions for females, although generally lower than those for males, also did not exhibit any distinct pattern. This general finding was supported by detailed investigation of the individual surveys.

Ethnic Origin

Following investigations of blood lead concentrations in Birmingham children there was some concern about Asian children, who appeared to have higher blood lead concentrations than white children living in the same environment[8]. So in the 1981 surveys a question was added on ethnic origin. Interviewers were asked to distinguish between white, African/West Indian, Indian/Pakistani/Bangladeshi and "other". In most areas however, so few non whites were covered in the surveys that results are not reliable. Nevertheless, what overall results we do have do not indicate any significant differences in blood lead concentrations between white and non white children nor between white and non white adults. In the survey of Bangladeshi infants which was carried out in the London borough of Tower Hamlets in an area of older housing generally in poor condition, a smaller "control" group of non asian children from the same area was also included. It was found that 87% of the non asian infants had blood lead concentrations under 20 µg/100ml, as had 96% of the Bangladeshi infants; no child was above 35 µg/100ml.

These results contrast with those from America, where studies [7, 9] have found consistent differences between people of different ethnic origin. Blood lead levels in blacks were higher than in "hispanics" who in turn had slightly higher levels than whites. However, it should be noted that blood lead levels in America were generally much higher than those in the UK.

Smoking and Drinking Habits

As tobacco smoke contains lead, participants in the blood lead surveys were asked about their smoking habits. Unfortunately, the form used in 1979 did not differentiate non smokers from those smoking less than 5 cigarettes a day. But smokers generally had higher blood lead concentrations - about 2 µg/100ml higher on average. Concentrations of under 10 µg/100ml were much less common in heavy smokers. The same pattern was found for women. About 15 per cent of men smoked cigars or a pipe; they showed slightly raised average blood lead concentrations.

The form was modified for the 1981 surveys, and so the first histogram in Figure 11 is for non smokers only. As in 1979, heavy smokers had higher blood lead concentrations - again about 2 µg/100ml higher on average. People who smoked from 1 to 20 cigarettes a day had intermediate blood lead levels. These results are similar to those from the Regional Heart Study[10].

It had been hoped that it would be possible to relate blood lead levels to drinking habits, but unfortunately the question was phrased in such a way that it was not possible to relate blood lead to the amount of drink consumed. In the Regional Heart Study, the effect of heavy drinking was found to be about twice that of heavy smoking; and the effects were cumulative.

Age of Dwelling

People living in pre 1945 dwellings generally had higher blood lead concentrations than those living in post 1945 dwellings; the average difference for men and for women was about 2 µg/100ml (Figure 12). Dwellings built before 1945 are more likely to have lead plumbing and to contain old lead based paints.

Length of Residence

Blood lead concentrations did not seem to be related to length of residence. This finding is not as surprising as it might at first appear, because there is evidence that blood lead concentrations respond quite rapidly to increases in exposure to a source of lead pollution[11]. Although on removal of the source blood lead levels fall at a slower rate than they rise on exposure, the time scale is still relatively short (months rather than years) and thus within a year or so a person's blood lead is likely to have adjusted to the sources of lead pollution in the environment.

Lead in Drinking Water

Reference has already been made above to surveys in areas where the water dissolved lead from pipes: the random surveys of adults and the Duplicate Diet Study of mothers and infants in Glasgow in 1979, and the survey of mothers with young children in Ayr in 1981, all of which breached the EEC reference levels.

In Ayr, where the levels of lead in the drinking water were among the highest in Great Britain, the average blood lead concentration of the mothers was nearly twice the average for women in inner city areas (Figure 13).

In Glasgow, the water authority (Strathclyde Regional Council) introduced lime dosing of almost all the city's water supplies. That programme achieved substantial reductions of lead in water, and enhanced lime dosing was introduced in 1980. In the random survey of adults in 1981, the mean blood lead levels for both men and women were about 20 per cent lower than those in the 1979 survey.

Preliminary results from the partial follow up of the 3 month old infants in the Duplicate Diet Study on their second birthdays indicate that their blood lead levels were about 35 per cent lower than would have been expected (allowing for the effect of age) had the water not been treated.

Exposure to Leadworks

The distributions shown in Figure 14 are typical of those found in leadworkers' children and children living near leadworks. Although it is not possible to compare them with the levels in the general population, the average blood lead concentrations were considerably higher than those found in children living near major roads.

Children living near leadworks were coded according to the distance they lived from the works. Generally, blood lead concentrations declined as distance increased (Figure 15). At Chester, the average level in a group of children who attended a school near the works but lived outside the area was 4 µg/100ml lower than those in the outer ring.

Major Roads

(i) Adults

In the London borough of Brent, those adults living in houses directly fronting the North Circular Road had only a slightly higher average level than the rest of the sample (Figure 16). The average blood lead concentration in the 1979 survey of adults living within 100 metres of the M4 motorway in Hillingdon, west London, was slightly higher than the general outer London level although no individual was above 25 µg/100ml. But the Hillingdon blood samples were taken by the capillary method, and it is strongly suspected that many samples were contaminated. A similar survey was carried out in 1981, together with a "control" group who lived in another part of the borough. An expert phlebotomist was employed to take the blood samples. Both the adults near the M4 and the control group had blood levels well below those found in 1979, and were similar to those found elsewhere in outer London. Although the average level in the control group was apparently higher, the group contained relatively more men and relatively more people living in older dwellings than in the M4 survey; after adjusting for sex and age of dwelling, the averages were almost the same.

As mentioned above, the surveys of adults in 1981 were directed more closely towards possible problem areas: in addition to Hillingdon, there were eight surveys of adults living near major roads: most of those were also areas of predominantly older housing (Figure 17). Compared with the random surveys in 1979, the average blood lead concentration in Gravelly Hill was similar to those in the Birmingham inner city surveys; the average level for the Liverpool Ring Road survey was similar to the other Liverpool surveys; and the average levels in the 1981 surveys near major roads in Islington, Manchester, Sheffield and Waltham Forest were all somewhat lower. Thus it would appear that blood lead concentrations in people living near major roads were not very different from those in the general population in the same area. However, there was the same distinct geographical pattern as the random surveys in 1979, with the lowest levels in London and the highest in Liverpool and Manchester.

(ii) Children

Three different types of area were chosen in 1979 to study children living near major roads (Figure 18); the Hillingdon survey was repeated in 1981. The surveys are not directly comparable because of the different topography of each area, the different ages of the children, and the different methods of blood sampling.

A group of children below the age of 7, living in a densely populated area of older housing near Borough Road in Tower Hamlets in east London apparently had slightly elevated blood lead levels, but allowance must be made for the effect of age, and of age of dwelling, and for the blood samples being capillary, not venous.

In the survey of a group of children living near the M62/A653 interchange at Tingley near Leeds, a rural area with good dispersion, average levels were low, about 11 µg/dl. The average concentration fell slightly as the distance from the road increased.

In the 1979 survey of children living near the M4 motorway in Hillingdon, the average blood lead concentration was about 2 µg/100ml higher than the adults. But, as in the survey of adults in Hillingdon, blood samples were taken by the capillary method, and again it is suspected that many samples were contaminated. In 1981, the same expert phlebotomist who took the adults' blood samples also took the blood samples from the children. The overall results were generally low, and fairly similar to those obtained at Tingley.

Comparisons Between 1979 and 1981

There are difficulties in attempting to compare the 1981 surveys with those in 1979 when the surveys of adults were random samples in inner and outer urban areas. Where surveys were carried out by the same local authorities in 1981, the geographical areas within each authority were different and were chosen because they were a potential problem, containing either predominantly older housing or major roads (or both).

Those 1981 surveys involving major roads have been mentioned above. Of the eight, one city (Bristol) was not sampled in 1979, and two had roughly the same average blood lead concentrations as broadly comparable 1979 surveys (Gravelly Hill; Liverpool); one was lower by about 5 per cent (Waltham Forest), two by about 10 per cent

(Islington, Archway and Hornsey Roads), one by about 15 per cent (Manchester) and one by about 20 per cent (Sheffield).

In addition, again standardising for sex, the 1981 survey in Brent (Harlesden) was almost 10 per cent lower than the 1979 survey near the North Circular Road, and Duddesdon was similar to the 1979 survey in Sutton Coldfield. The random survey in Lambeth was about 20% lower than a similar survey in 1979, but in both years there may have been some bias in the results because the response rates were very low.

For children, it is possible to make some direct comparisons, since some children sampled in 1979 were sampled again in 1981. The relationship between the blood lead concentrations in the two surveys for leadworkers' children and children living near the leadworks at Thorpe in Leeds is illustrated in Figure 19. The pictures from the other leadworks are similar to this one. Even with the very high level of variability in blood lead concentrations it is clear that there has been an overall reduction in levels of around 15 per cent. Several factors may be involved: an increased general awareness of the problem of lead pollution; action taken at the factories to reduce emissions and improve hygiene; lowering of economic activity.

SURVEYS IN THE OTHER EEC COUNTRIES

In the nine countries of the EEC, the 170 surveys carried out in 1979 included 18,000 people. According to the Commission's report[12], the participants were almost equally divided between the sexes. The proportions of children ranged from zero in France to around 50 per cent in West Germany and the UK and to over 70 per cent in the Netherlands. Although it is not really meaningful to mix together results from diverse types of surveys in different countries, many of which involved known exposure to lead, the overall median blood lead concentration was 13 µg/dl; 2 per cent were over 30 µg/dl and 1.05% were over 35 µg/100ml. Blood lead concentrations in the general population will almost certainly be below these levels. As was found in the UK surveys, blood lead concentrations in women were "a few µg/100ml lower than in men".

Breaches of the Reference Levels

Those surveys which breached the reference levels are shown in Figure 20. Two adult surveys breached all three levels; two adults and two child surveys breached the 30 and 35 µg/100ml; and seven adult and five child surveys breached only the 35 µg/100ml level.

In Belgium, the survey in Verviers breached all three reference levels. The problem there was similar to that in Glasgow and in Ayr, with lead plumbing and water that dissolves lead from pipes. Other surveys, for example near an Antwerp lead smelter, were close to the reference levels. In Denmark, all surveys were well below the reference levels. Two surveys, near a battery works and a lead smelter in Germany breached the reference levels. At the first, "17 children were sent on a state paid vacation in a resort area to reduce (their) exposure". At the second, the local government "initiated a situation analysis". The surveys in France were nearly all of adults not exposed to particular sources of lead, and were generally satisfactory, although one survey did breach the upper reference level. There was no general or specific lead problem in Ireland: 94 per cent of those sampled were under 20 µg/100ml; none were over 35 µg/100ml. In Italy, one survey near a lead smelter breached all three reference levels. Action was taken on the production processes, the efficiency of abatement measures and workers' personal hygiene. One survey of inner urban adults not exposed to a source of lead breached both the 30 µg/100ml and 35 µg/100ml levels. Two other surveys of adults (one group not exposed) breached the upper reference level. No-one sampled in Luxembourg was over 35 µg/100ml. The surveys in the Netherlands concentrated on children. The blood lead concentrations of inner urban children were highest, but all child surveys were below the reference levels. One adult survey in Amsterdam breached the 35 µg/100ml level.

The six UK surveys which breached the reference levels in 1979 have been mentioned above. Although more surveys breached the reference levels than in any of the other countries, two of the surveys were stratified, not random. The random survey of adults in Glasgow breached only the upper level, whereas the similar survey in Belgium breached all three levels. The three leadworks surveys also breached only the upper reference level, whereas a similar survey in Italy breached all three levels. And several of the surveys in other countries which breached the reference levels were of groups not exposed to a particular source of lead. All such groups in the UK met the reference levels quite comfortably.

Levels in the EEC Countries

To give some idea of how levels compared among the countries, the surveys have been grouped into four types. All countries sampled adults in inner urban areas not exposed to a particular source of lead (Figure 21). The countries are arranged in descending order of median blood lead concentration. Not all countries included surveys in the other three categories. But where they did, the rank order was similar to that in the first category. Wherever there were surveys in Belgium in a particular category, the median level was the highest. Italian levels were also high. Levels in Germany were consistently among the lowest. This also applies to the surveys of children (Figure 22).

There are, however, problems with these simple comparisons:

(i) there is the possibility of measurement bias. But in addition to a laboratory's own calibration procedures, a rigorous common quality assurance scheme was used by all participating laboratories. The scheme involved measuring specially supplied samples with known concentrations of lead. As a further check, 10 per cent of each laboratory's samples were interchanged with another laboratory. Two laboratories in the UK did not comply with the limits laid down. Their samples were redistributed to other UK laboratories;

(ii) within the broad categories, surveys may be of areas which differ in, for example age of housing, topography or water supply;

(iii) surveys may consist of different proportions of males and females, different proportions of younger and older children, different proportions of smokers and non smokers, etc;

(iv) samples may not be representative of the area from which they are drawn; and

(v) different national characteristics may affect levels, eg metabolism or diet.

SUMMARY

The surveys in the UK in 1979 showed that blood lead concentrations in the random surveys of adults were generally well below the EEC reference levels. The results from the surveys of adults in 1981, in which the emphasis was placed on specific sources of exposure such as older housing or major roads, were also generally well below the EEC reference levels. Whenever a person was found to have a high blood lead, follow-up investigation showed this to be the result of exposure to a specific source.

Blood lead concentrations were approximately lognormally distributed. Blood lead levels were higher in inner urban areas than in outer areas (by about 2 µg/100ml on average); higher in the north than in London (by between 3 and 5 µg/100ml); higher in 2 and 3 year olds than in other children (by about 3 µg/100ml); higher in men than in women (by 3 to 4 µg/100ml); and higher in people living in older dwellings (by about 2 µg/100ml). There were only very small differences in average blood lead concentrations between boys and girls up to the age of 12, and levels in adults did not seem to increase with age. There did not appear to be any differences among the social classes, among people of different ethnic origin, nor with length of residence.

There was evidence of considerably raised blood lead concentrations in adults and children in Glasgow, and in Ayr where the average level for mothers with young children was over 20 µg/100ml - nearly twice the average level for women in inner city areas. In both places, the water dissolved lead from pipes. Following remedial action taken by the water authority in Glasgow, the 1981 surveys showed that the blood lead concentrations of adults were generally lower by about 20 per cent, and those of the 2 year old children by about 35 per cent.

For children exposed to leadworks, blood lead concentrations consistently declined as distance from the works increased. Average levels were considerably higher than those found in children living near major roads.

The surveys of adults living near major roads showed that blood lead concentrations were only marginally higher in those fronting a road, and were not very different from those in the general population in the same area. However, the levels in the north were noticeably higher than those in London (by 3 to 4 µg/100ml).

Comparisons between the 1979 and 1981 surveys are difficult because in most cases in 1981 attention was directed more towards possible problem areas. However, where broad comparisons can be made, the levels in 1981 were either about the same as or somewhat lower than those in 1979. For children exposed to leadworks who were sampled in both 1979 and 1981, there were overall reductions of about 15 per cent in blood lead levels: several factors, including increased awareness of the problem of lead pollution, may have contributed.

Although there are problems with comparisons of the UK results with those for other countries in the EEC, blood lead levels in the UK were about in the middle of the range. Levels in Belgium and Italy were always the highest; those in Denmark, Germany and the Netherlands were among the lowest.

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12. Progress Report on the Implemention of the Directive (77/312/EEC), COM (81) 88 final; Commission of the European Communities, Brussels, 10 March 1981.

LOCATION OF SURVEYS IN UK 1979

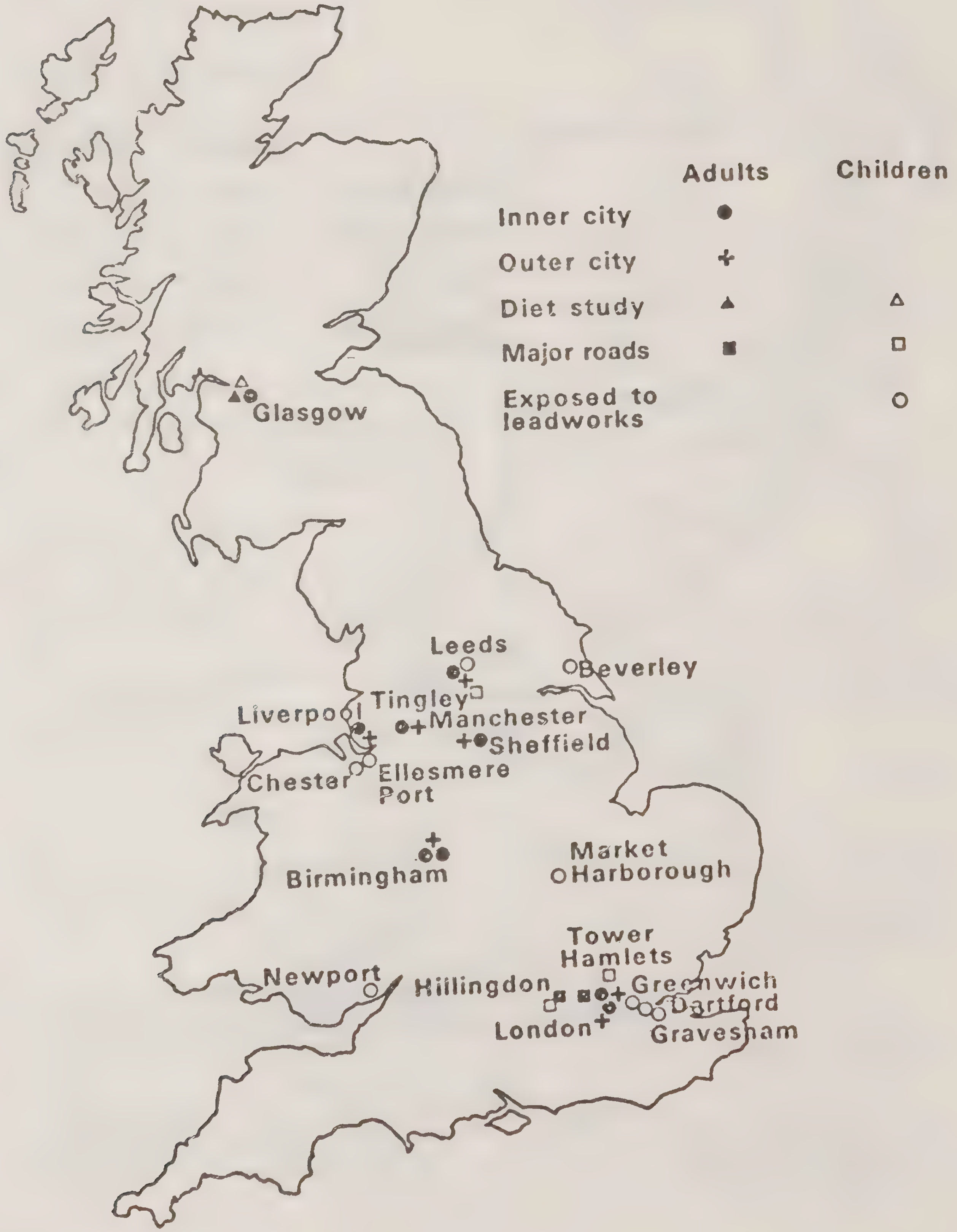


FIGURE 1

LOCATION OF SURVEYS IN UK 1981

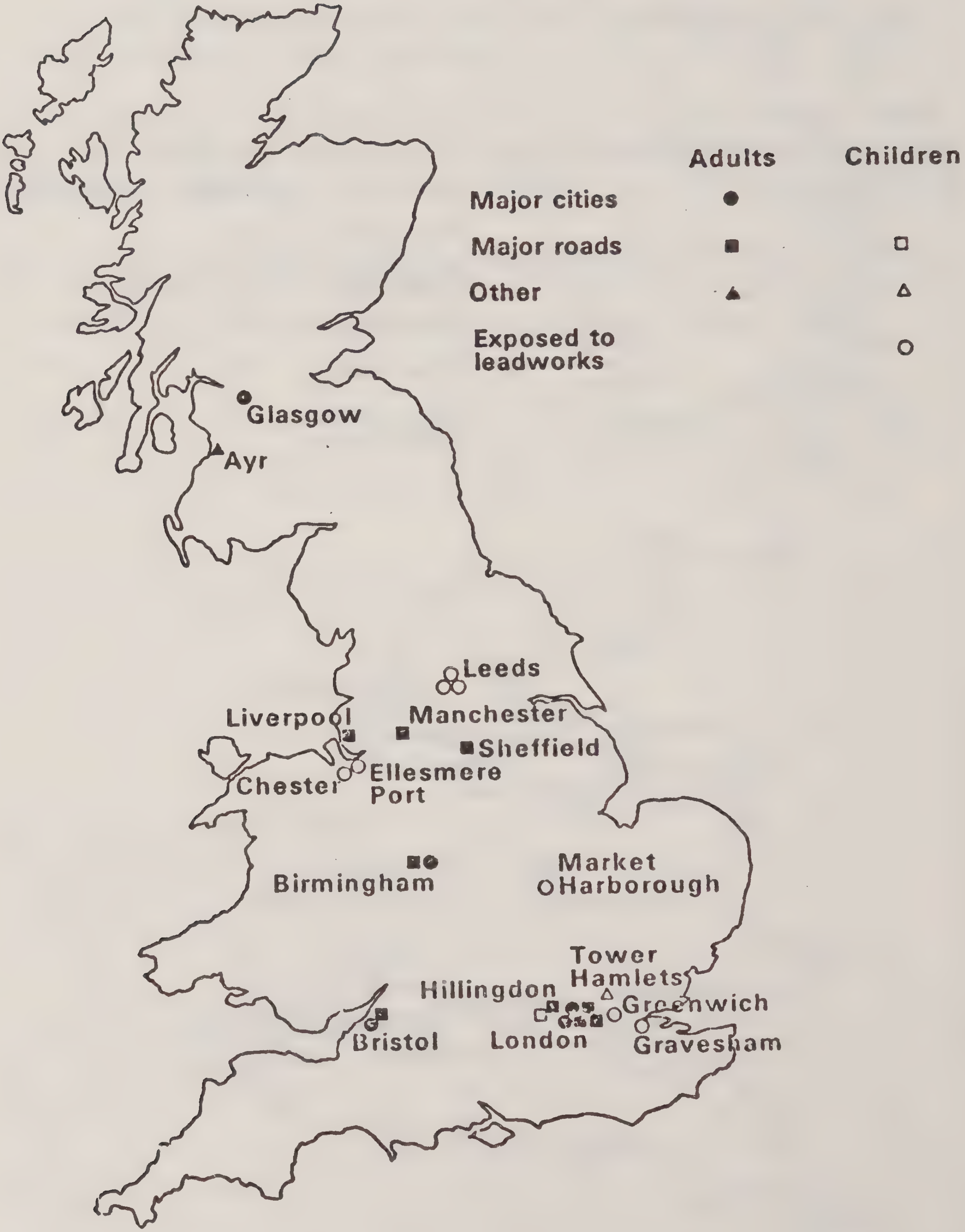


FIGURE 2

Identification number

2.1	2.2	2.3	2.4
0 9	☐☐☐☐	☐☐☐	☐☐☐☐

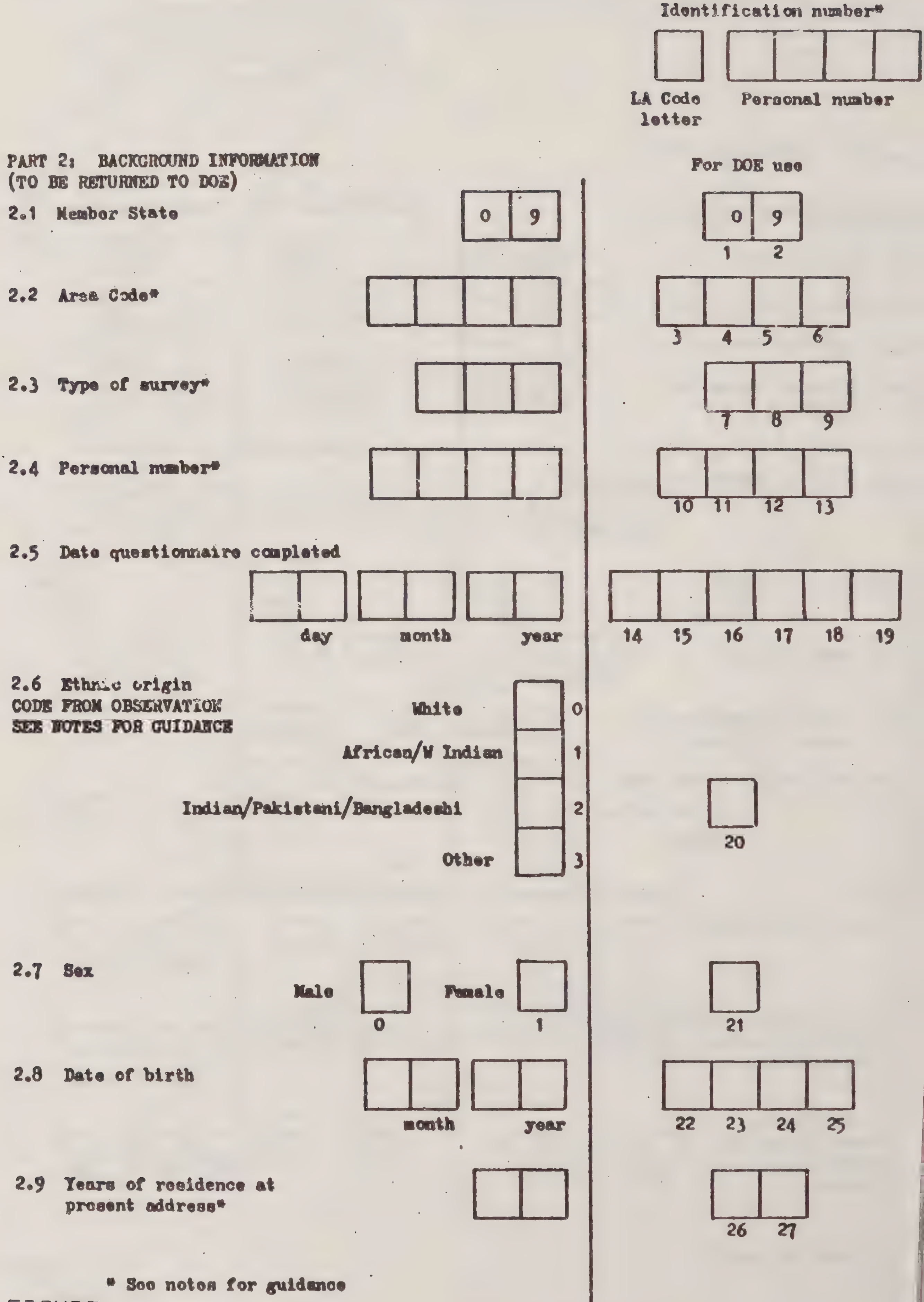
Part 2: BACKGROUND DATA

Identification number		For DOE use	For EEC use
2.1 Member State	0 9	0 9	☐☐ 1,2
2.2 Area Code *	☐☐☐☐	☐☐☐☐	☐☐☐☐ 3-6
2.3 Type of Survey *	☐☐☐	☐☐☐	☐☐☐ 7-9
2.4 Personal number of subject *	☐☐☐☐	☐☐☐☐	☐☐☐☐ 10-13
2.5 Date questionnaire completed	☐☐ ☐☐ ☐☐ day month year	☐☐ ☐☐ ☐☐	☐☐ ☐☐ ☐☐ 14,15 16,17 18,19
2.6 Sex Male	0 ☐		☐ 20
Female	1 ☐	☐	☐ 21
2.7 Date of birth	☐☐ ☐☐ month year	☐☐ ☐☐	☐☐ ☐☐ 22,23 24,25
2.8 Years of residence at present address	☐☐	☐☐	☐☐ 26,27
2.9 House built before 1945	1 ☐		
after 1945	2 ☐	☐	☐ 28
unknown	3 ☐		

2.10	Present	Previous	Present	Previous	Present	Previous
2.10.1 Occupation*	☐☐	☐☐	☐☐	☐☐	☐☐ 29,30	☐☐ 31,32
2.10.2 Number of years in the occupation corresponding to 2.10.1	☐☐	☐☐	☐☐	☐☐	☐☐ 33,34	☐☐ 35,36
2.10.3 Medical surveillance for occupational lead exposure	☐ ☐ yes no	☐ ☐ yes no	☐	☐	☐ ☐ 37, 39	☐ ☐ 38, 40

* Refer to notes

FIGURE 3



Identification number*

☐ ☐☐☐☐

LA Code letter — Personal number

PART 2: BACKGROUND INFORMATION (TO BE RETURNED TO DOE)

		For DOE use
2.1 Member State	0 9	0 9 1 2
2.2 Area Code*	☐☐☐☐	☐☐☐☐ 3 4 5 6
2.3 Type of survey*	☐☐☐	☐☐☐ 7 8 9
2.4 Personal number*	☐☐☐☐	☐☐☐☐ 10 11 12 13
2.5 Date questionnaire completed	☐☐ day ☐☐ month ☐☐ year	☐☐☐☐☐☐ 14 15 16 17 18 19
2.6 Ethnic origin CODE FROM OBSERVATION SEE NOTES FOR GUIDANCE	White ☐ 0 African/W Indian ☐ 1 Indian/Pakistani/Bangladeshi ☐ 2 Other ☐ 3	☐ 20
2.7 Sex	Male ☐ 0 Female ☐ 1	☐ 21
2.8 Date of birth	☐☐ month ☐☐ year	☐☐☐☐ 22 23 24 25
2.9 Years of residence at present address*	☐☐	☐☐ 26 27

* See notes for guidance

FIGURE 4

UK BREACHES OF THE EEC REFERENCE LEVELS

year	place	survey	level(s) breached	% over 35 ug/dl
1979	Chester	leadworkers' children	35	6
	Chester	children living near works	35	7
	Glasgow	infants, diet study*	30,35	11
	Glasgow	mothers, diet study*	35	5
	Glasgow	random adults	35	4
	Leeds	leadworkers' children	35	3
1981	Ayr	mothers with young children	20,30,35	17
	Gravesham	leadworkers' children	35	2.3
	Islington	adults, Archway Road	35	3

* these surveys were stratified and so were not random samples

FIGURE 5

DISTRIBUTION OF BLOOD LEAD CONCENTRATIONS: INNER MANCHESTER ADULTS

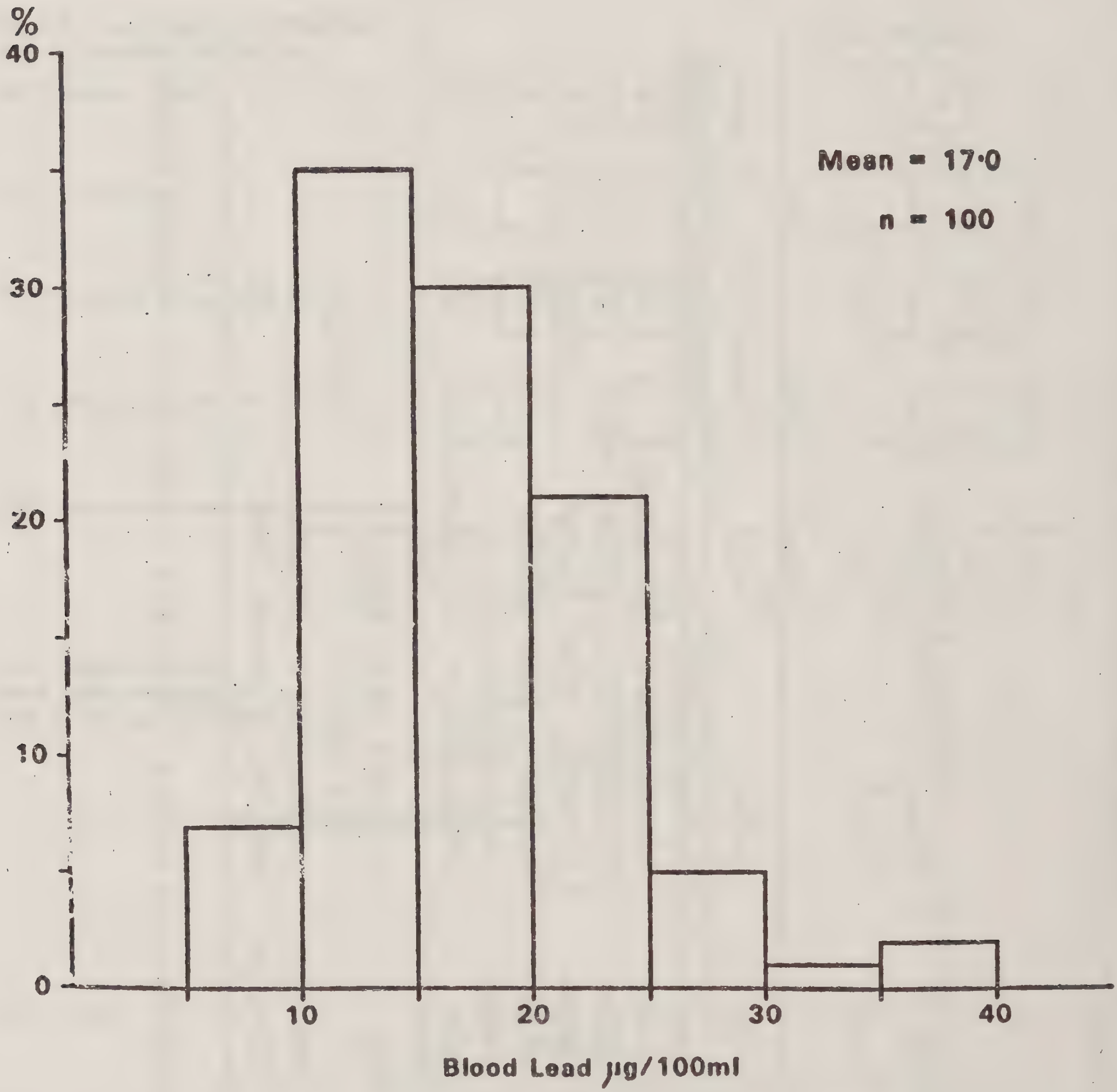


FIGURE 6

GEOMETRIC MEAN BLOOD LEAD LEVELS* BY AREA

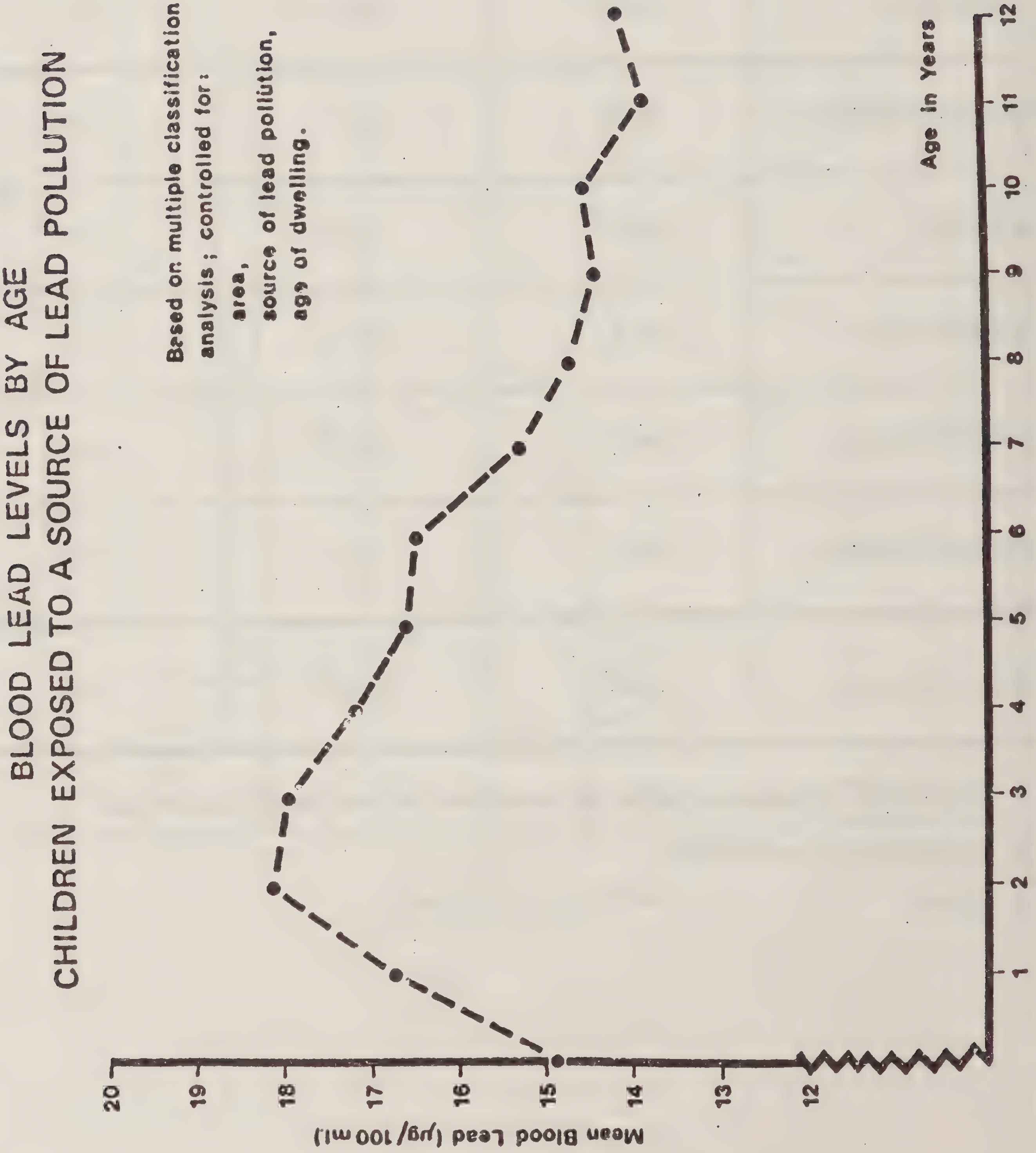
	INNER CITY	OUTER CITY	DIFFERENCE
LONDON	12·0[1]	10·2[1,2]	1·8
BIRMINGHAM	13·6	11·1	2·5
LEEDS	15·6	13·3	2·3
SHEFFIELD	14·6	13·2	1·4
LIVERPOOL	14·2	13·8[2]	0·4
MANCHESTER	17·0	16·6	0·4
ALL AREAS	12·8[1]	11·0[1,2]	1·8

[1] Weighted by total number of electors in each area surveyed.

[2] Adjusted for sex bias.

* µg/100ml

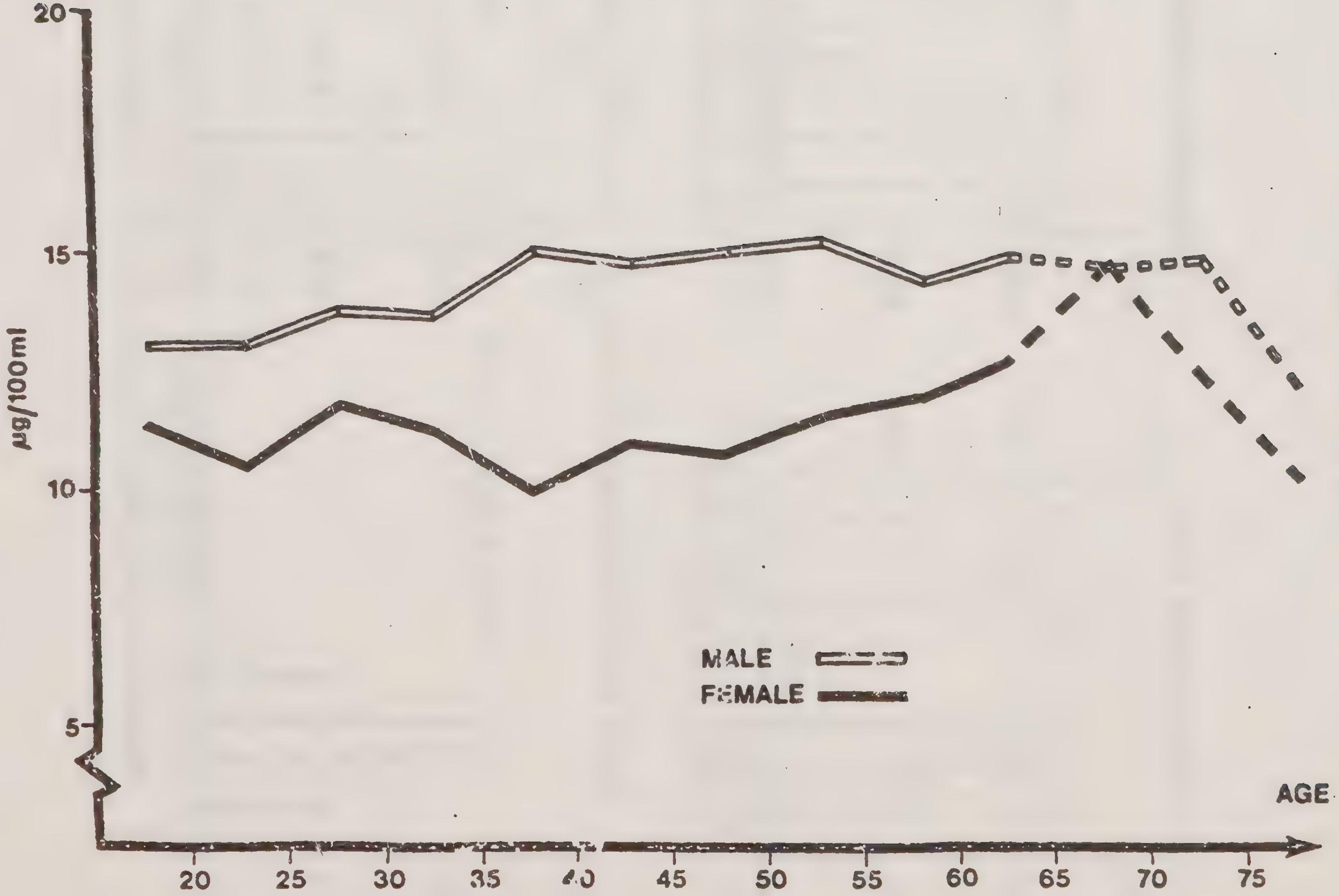
FIGURE 7



BLOOD LEAD LEVELS BY AGE
CHILDREN EXPOSED TO A SOURCE OF LEAD POLLUTION

Based on multiple classification analysis; controlled for:
area,
source of lead pollution,
age of dwelling.

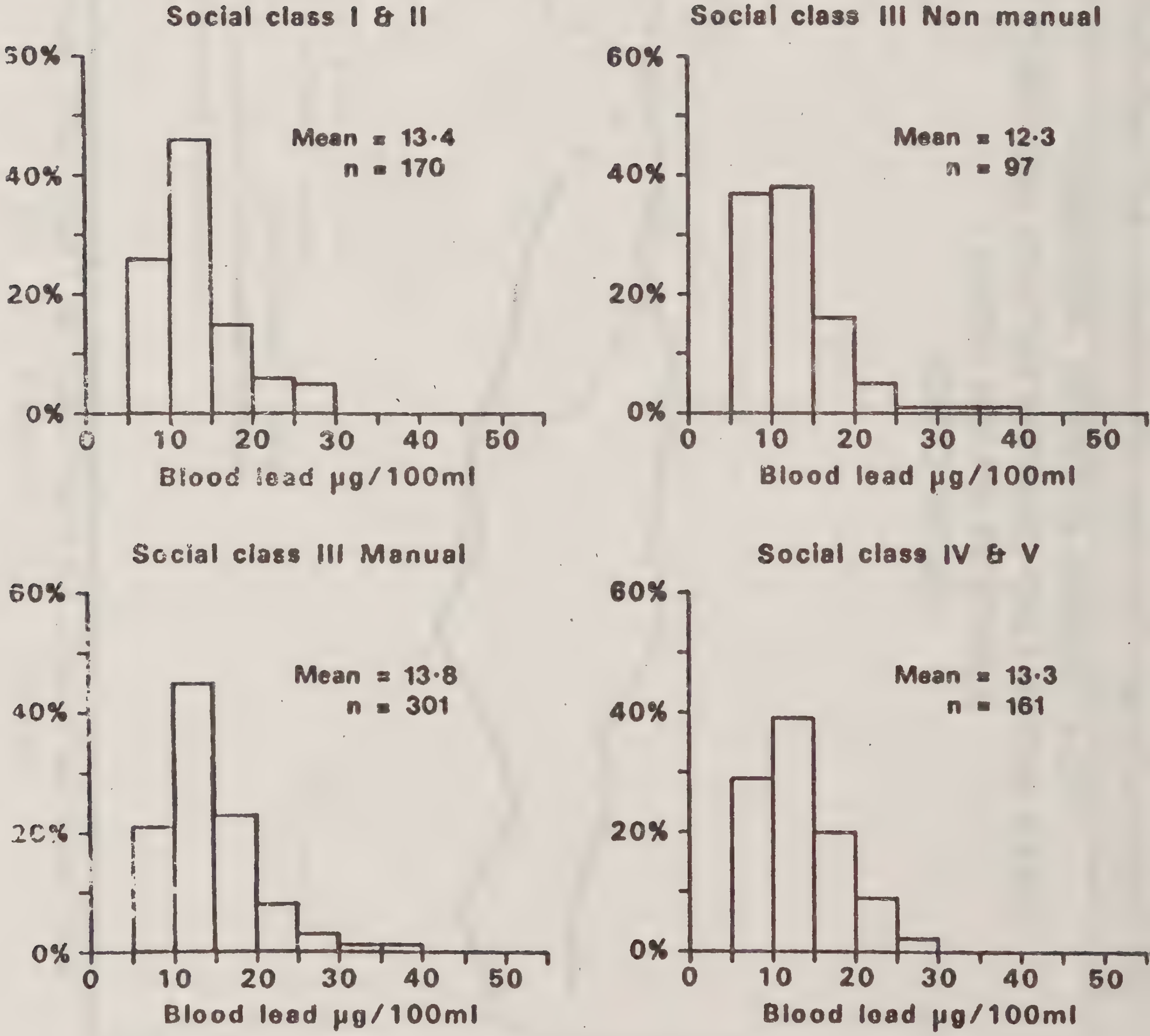
FIGURE 8



RELATIONSHIP BETWEEN ARITHMETIC MEAN BLOOD LEAD CONCENTRATIONS AND AGE:
ADULTS IN MAJOR CITIES
OUTER CITIES

FIGURE 9

DISTRIBUTION OF BLOOD LEAD CONCENTRATIONS
BY SOCIAL CLASS : ADULT MALES



Social class I & II

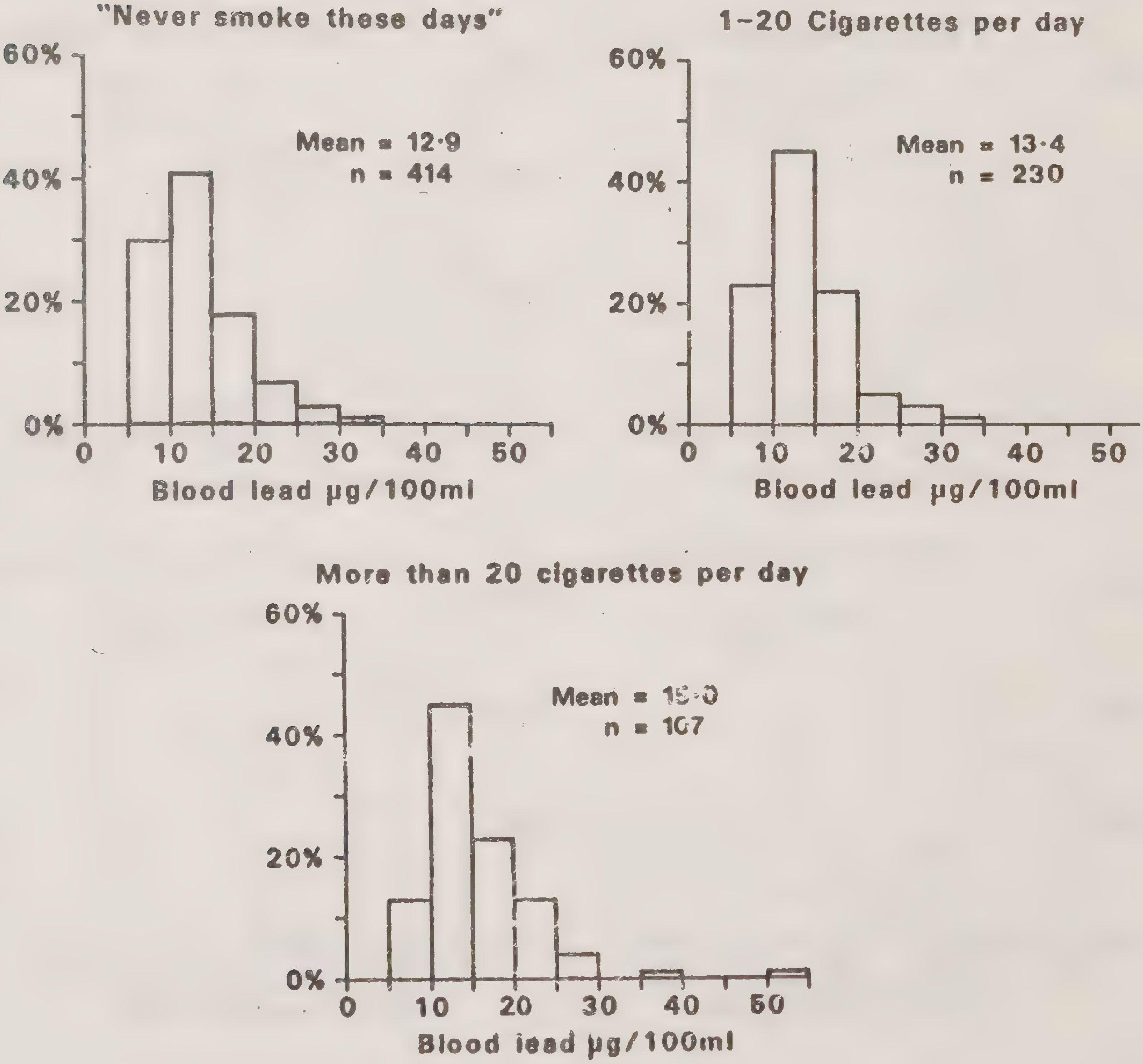
Social class III Non manual

Social class III Manual

Social class IV & V

FIGURE 10

FREQUENCY DISTRIBUTIONS OF BLOOD LEAD CONCENTRATIONS BY SMOKING HABITS (ADULT MALES)



"Never smoke these days"

Mean = 12·9
n = 414

1–20 Cigarettes per day

Mean = 13·4
n = 230

More than 20 cigarettes per day

Mean = 15·0
n = 107

FIGURE 11

DISTRIBUTION OF BLOOD LEAD CONCENTRATIONS BY AGE OF DWELLING AND SEX

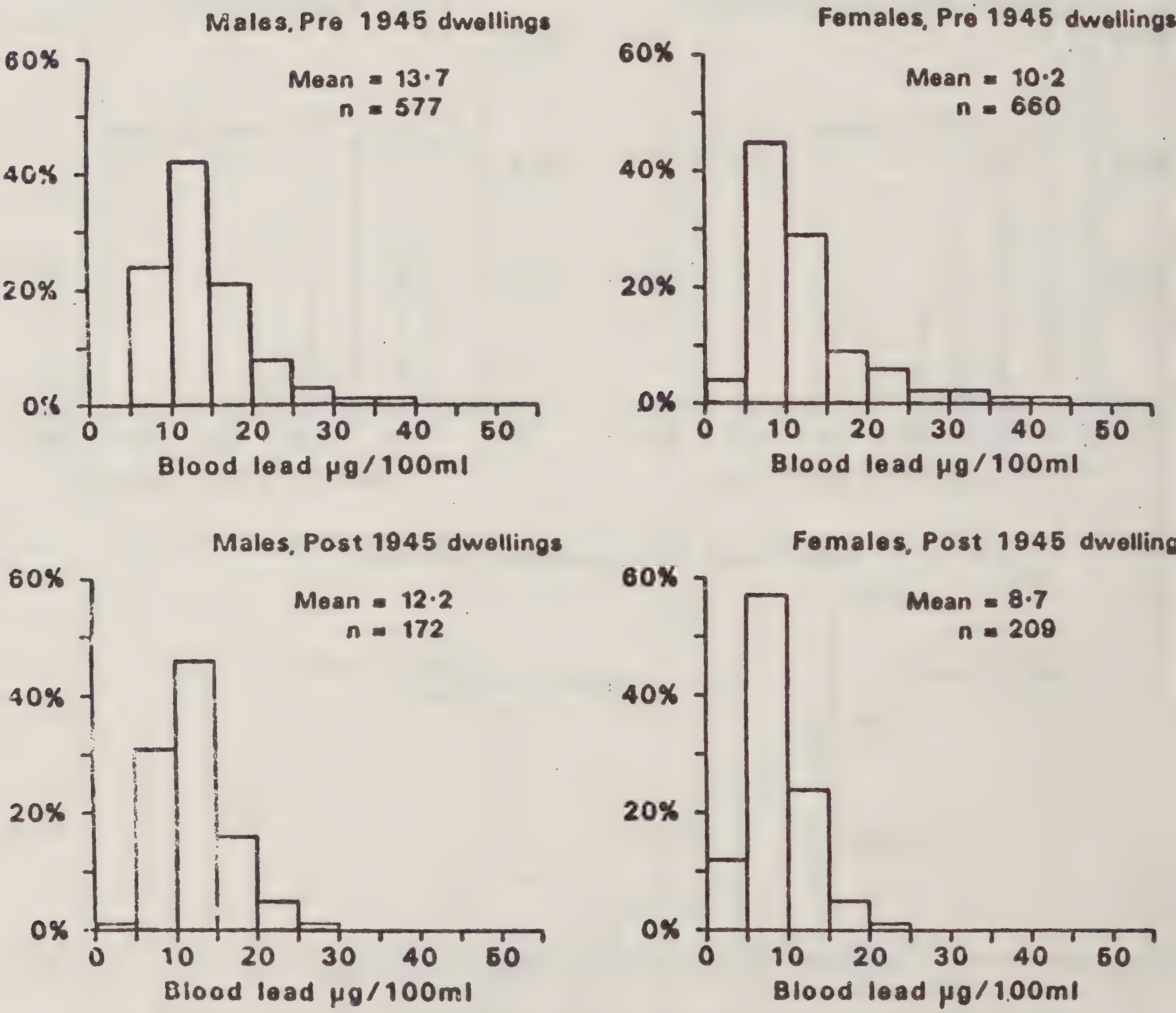


FIGURE 12

LEAD IN DRINKING WATER
DISTRIBUTION OF BLOOD LEAD CONCENTRATIONS
AYR: MOTHERS WITH YOUNG CHILDREN

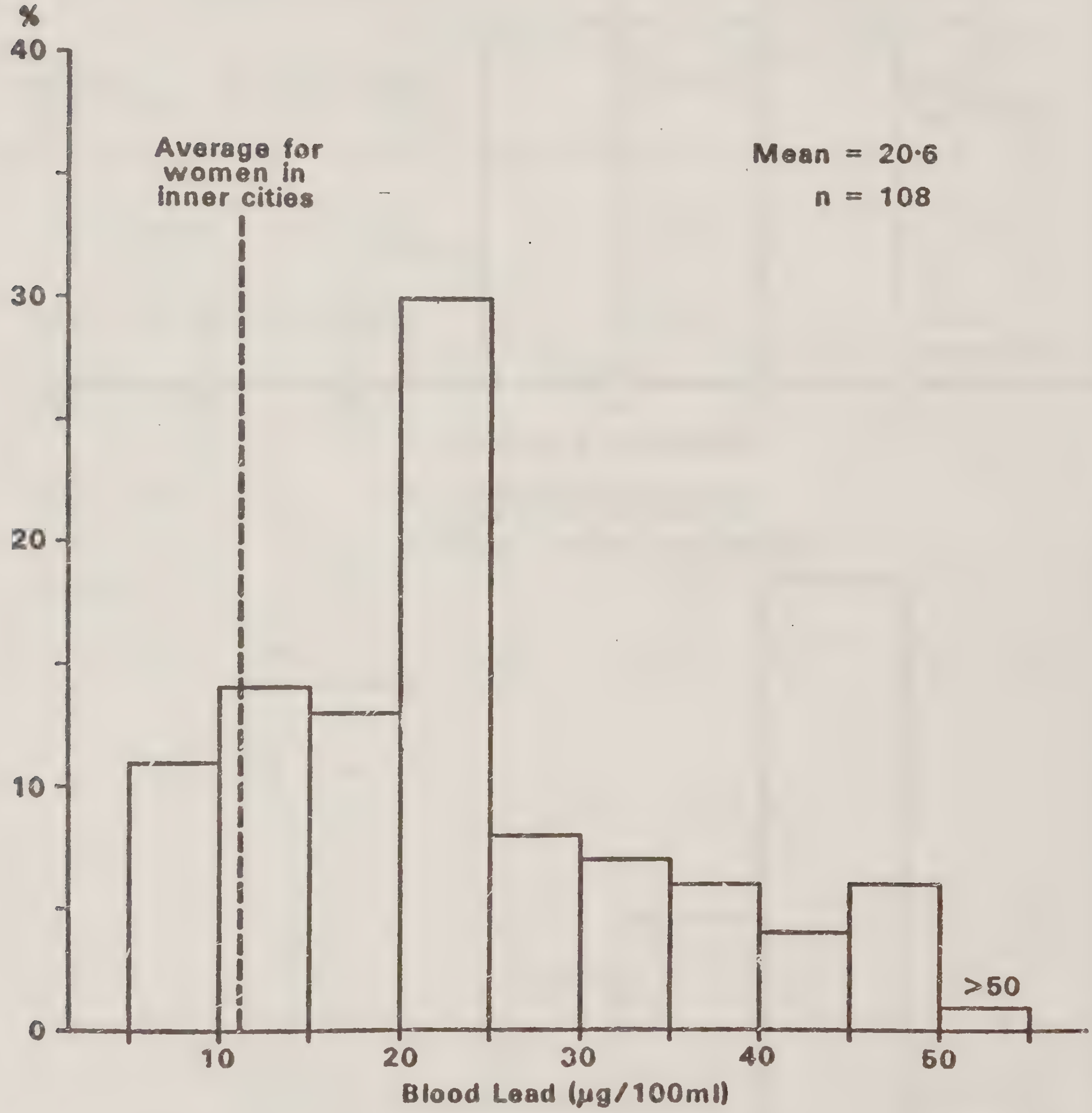
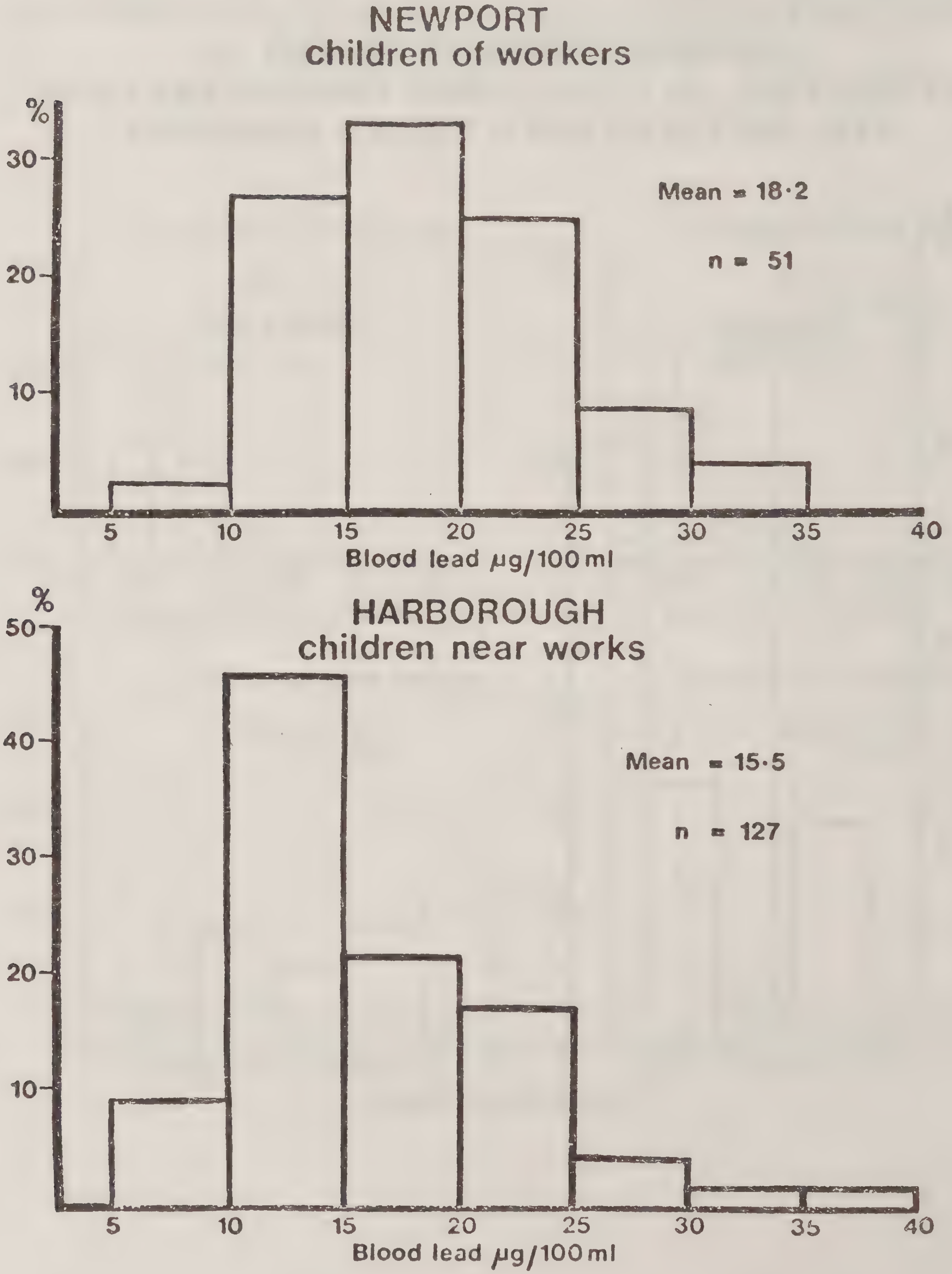


FIGURE 13



DISTRIBUTION OF BLOOD LEAD CONCENTRATIONS
CHILDREN EXPOSED TO LEADWORKS

FIGURE 14

BLOOD LEAD CONCENTRATIONS IN CHILDREN
LIVING NEAR LEADWORKS

DISTANCE FROM WORKS	GEOMETRIC MEAN BLOOD LEAD (µg/100ml)		
	THORPE (LEEDS)	CHESTER	MARKET HARBOROUGH
0 - 250 m	20.9	25.1	16.3
250 - 500 m	14.7	19.7	13.8
500 - 750 m	13.4	18.6	14.3
750 - 1000 m	13.8		
Controls	-	14.7	-

BLOOD LEAD CONCENTRATIONS IN ADULTS
LIVING NEAR MAJOR ROADS

YEAR	AREA	DISTANCE FROM ROAD	SAMPLE SIZE	GEOMETRIC MEAN BLOOD LEAD (µg/100ml)	
				UNADJUSTED	STANDARDISED†
1979	BRENT	Fronting Road*	68	11.8	-
	N. Circular Road	< 100 metres+	63	10.3	-
		> 100 metres	61	10.8	-
	HILLINGDON	< 100 metres	103	15.8@	-
	M4				
1981	HILLINGDON	< 100 metres	93	9.0	9.7
	M4	controls	65	11.0	10.0

*many dwellings were a considerable distance above the road
+excluding those fronting the road
@it is strongly suspected that many of the capillary blood samples were contaminated
†standardised for sex and age of dwelling

FIGURE 16

BLOOD LEAD CONCENTRATIONS IN ADULTS
LIVING NEAR MAJOR ROADS, 1981

AREA	SAMPLE	GEOMETRIC MEAN BLOOD LEAD		(µg/100ml)
		UNADJUSTED	STANDARDISED†	1979 SURVEY, STANDARDISED†
BIRMINGHAM Gravelly Hill	100	13.4	13.3	{ 13.3 { 13.7
BRISTOL Bath Road	104	13.5	13.1	[11.1]@
ISLINGTON				
Archway Road*	93	10.3	10.6	} 11.9
Hornsey Road	59	10.5	10.4	
LIVERPOOL Ring Road	100	14.5	14.8	14.4
MANCHESTER	100	14.2	14.5	16.7
SHEFFIELD Highfields and Lowfields	100	11.2	11.7	14.6
WALTHAM FOREST	100	9.1	9.1	9.7

† standardised for sex
*excluding three men with very high blood lead concentrations due to adventitious sources
@ 1981 survey, inner city area (Windmill Hill)

FIGURE 17

FIGURE 18

BLOOD LEAD CONCENTRATIONS IN CHILDREN LIVING NEAR MAJOR ROADS

YEAR	AREA	POPULATION SAMPLED	DISTANCE FROM ROAD	SAMPLE SIZE	GEOMETRIC MEAN BLOOD LEAD (µg/100ml)
1979	TOWER HAMLETS Borough Road	Children 0-6	n.a.	183	17.7
	TINGLEY, LEEDS M62/A653 Interchange	Children 0-12	< 250m	7	11.4
			250-500m	51	10.9
			500-750m	63	10.8
			750-1000m	156	9.8
	HILLINGDON M4	Children 0-12	< 100m	92	18.1[@]
1981	HILLINGDON M4	Children 0-12	< 100m	49	8.9

[@] it is strongly suspected that many of the capillary blood samples were contaminated

BLOOD LEAD CONCENTRATIONS 1979 AND 1981
CHILDREN NEAR LEADWORKS IN THORPE (LEEDS)

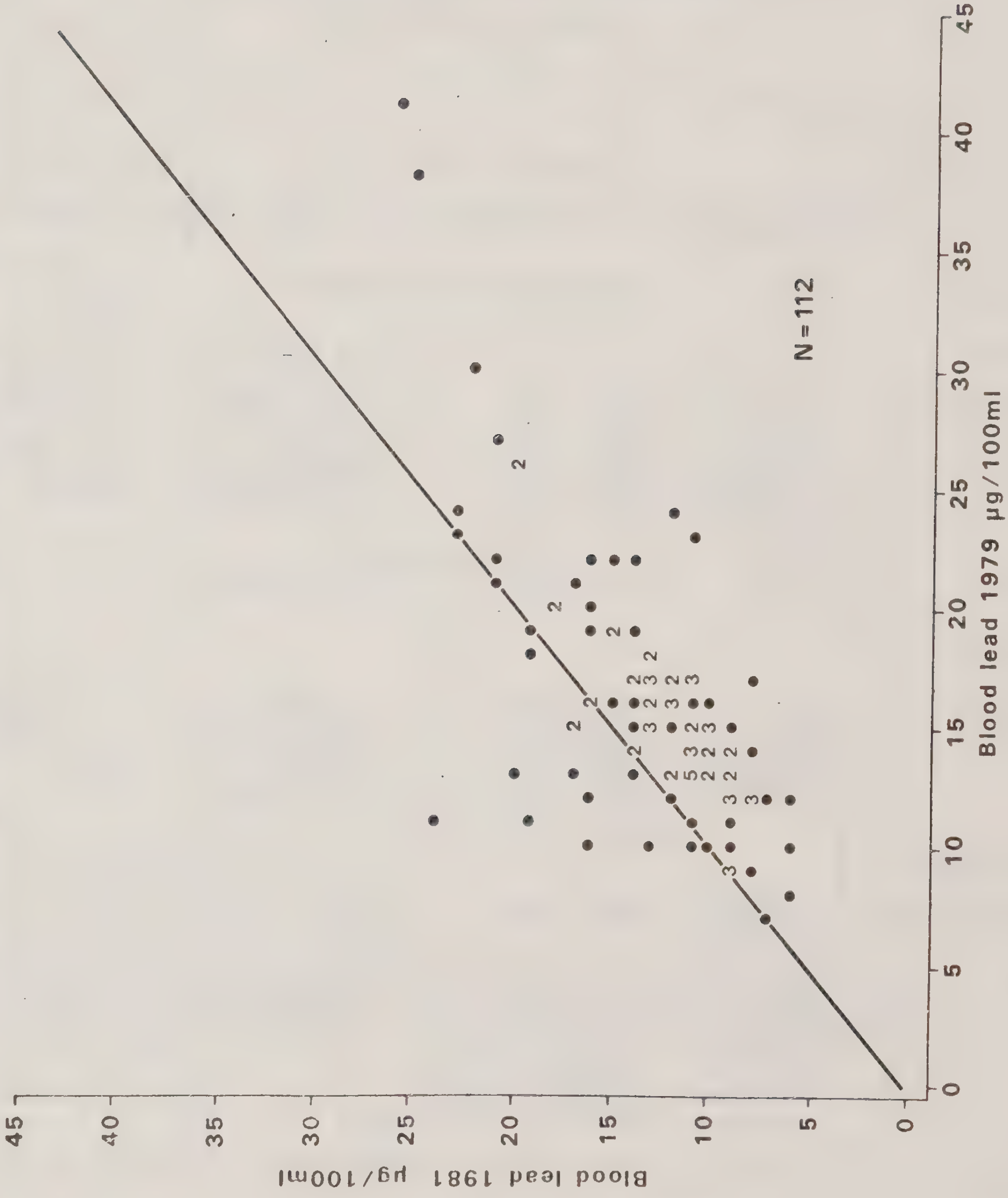


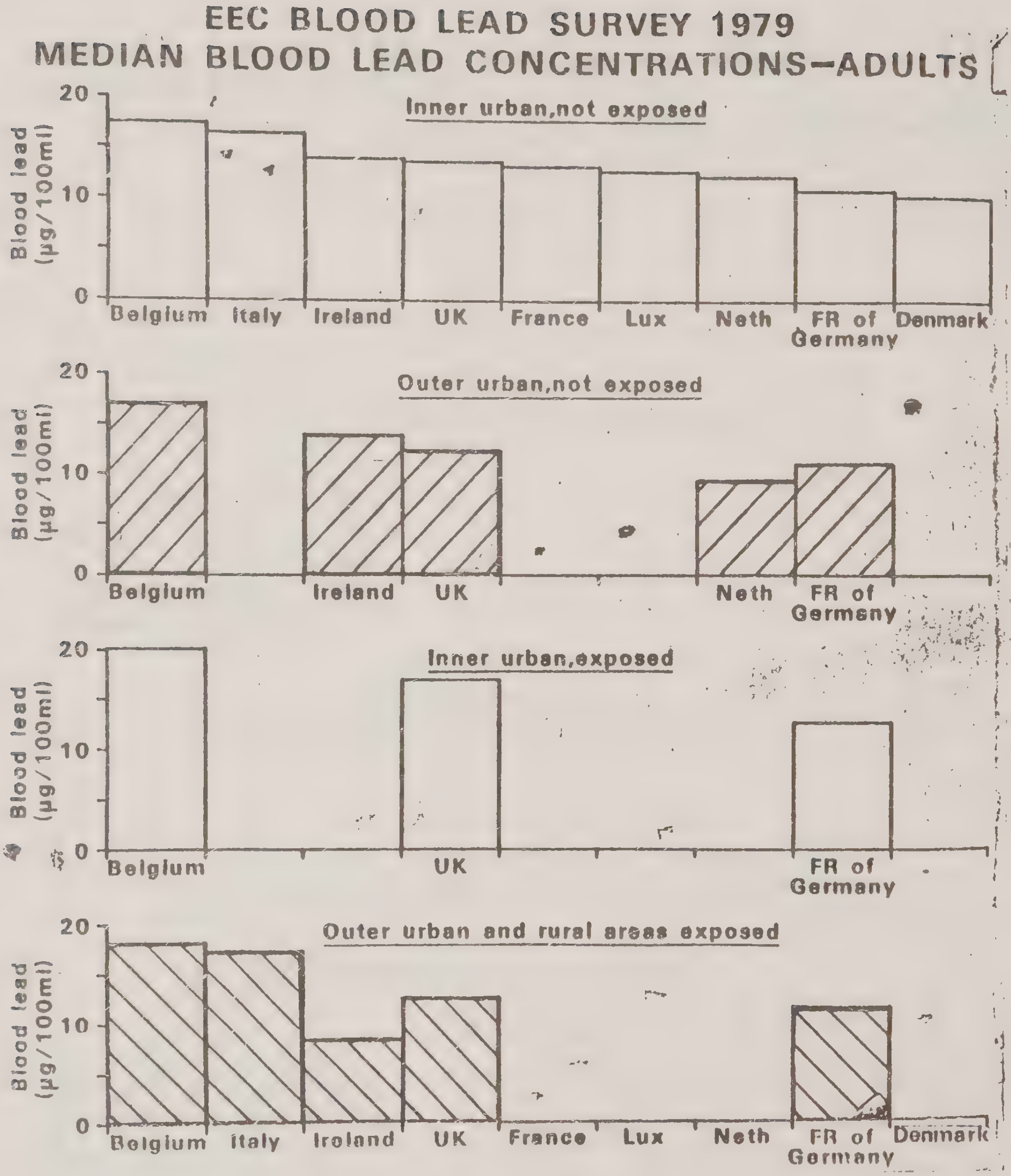
FIGURE 19

EEC BLOOD LEAD SURVEYS 1979

BREACHES OF THE REFERENCES LEVELS

country	type of survey			reference level(s) breached
Belgium	adults	inner urban	exposed	20,30,35
Denmark	–			
F R Germany	adults	rural area	not exposed	30,35
	adults	rural area	exposed	35
	children	outer urban	exposed	30,35
	children	outer urban	not exposed	35
	children	rural area	not exposed	35
France	adults	inner urban	not exposed	35
Ireland	–			
Italy	adults	outer urban	exposed	20,30,35
	adults	inner urban	not exposed	30,35
	adults	inner urban	exposed	35
	adults	inner urban	not exposed	35
Luxembourg	–			
Netherlands	adults	inner urban	not exposed	35
UK	babies	critical group at special risk		30,35
	mothers	inner urban	exposed	35
	adults	inner urban	exposed	35
	children	of leadworkers		35
	children	of leadworkers		35
	children	living near leadworks		35

FIGURE 20


EEC BLOOD LEAD SURVEY 1979
MEDIAN BLOOD LEAD CONCENTRATIONS–ADULTS

Inner urban,not exposed

Outer urban,not exposed

Inner urban,exposed

Outer urban and rural areas exposed

FIGURE 21

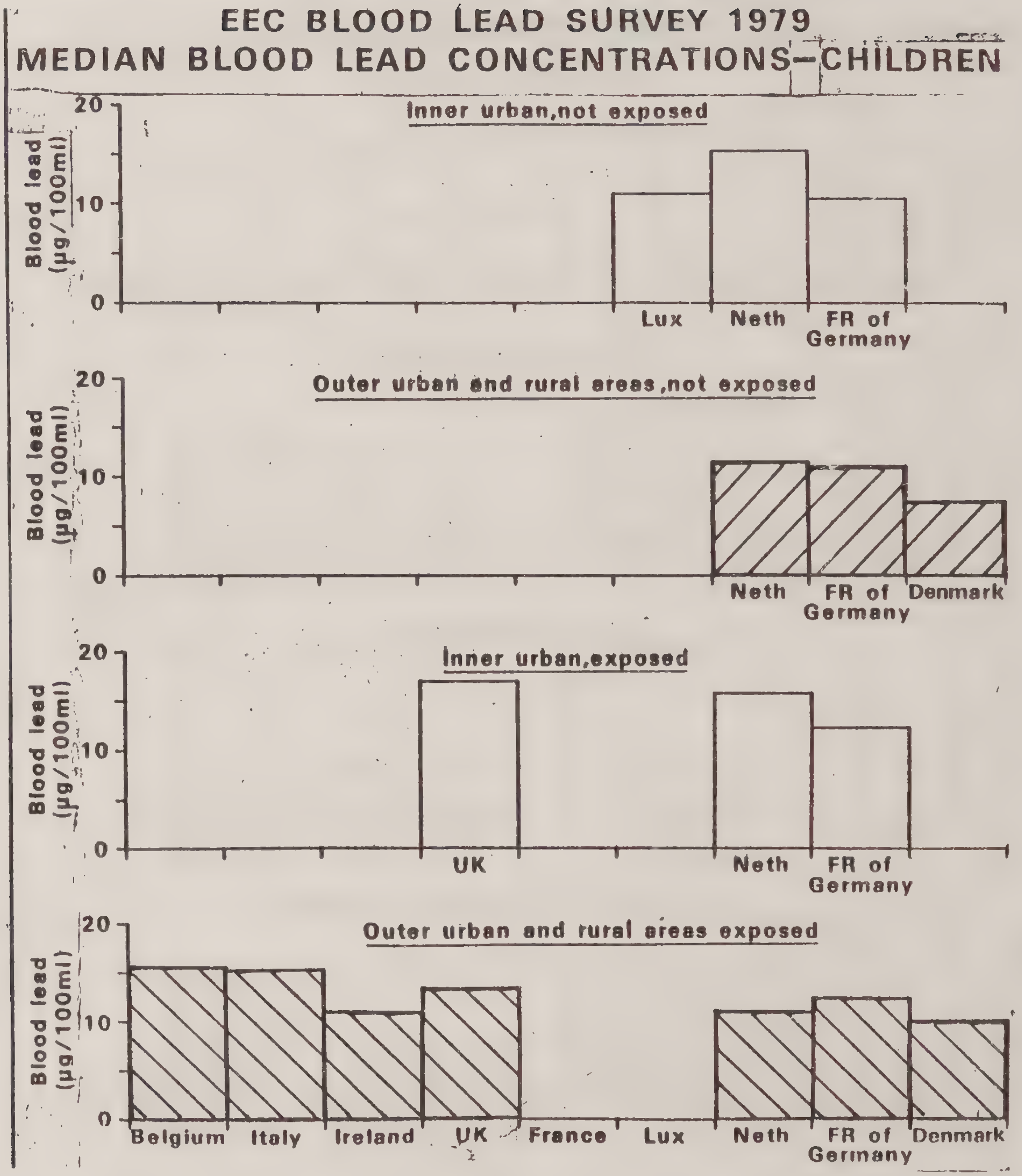

EEC BLOOD LEAD SURVEY 1979
MEDIAN BLOOD LEAD CONCENTRATIONS–CHILDREN
Inner urban,not exposed
Blood lead (µg/100ml)
20
10
0
Lux
Neth
FR of Germany
Outer urban and rural areas,not exposed
Neth
FR of Germany
Denmark
Inner urban,exposed
UK
Neth
FR of Germany
Outer urban and rural areas exposed
Belgium
Italy
Ireland
UK
France
Lux
Neth
FR of Germany
Denmark

FIGURE 22

nsca
49th ANNUAL CONFERENCE
21 OCTOBER 1982
LLANDUDNO

EFFECT OF AIR POLLUTANTS ON MATERIALS

By
Dr. K.G. Saunders
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INTRODUCTION

Partly as a celebration of the tenth anniversary of the UN Conference on the Human Environment, 1982 is also the year in which the 1979 UNECE* Convention on Long Range Transboundary Air Pollution will be ratified. The Convention was designed to combat effects of air pollution and to this end calls for strategies and policies to be devised for the implementation of the Convention. To provide a basis for these strategies, a cost-benefit analysis for various SO_2 emission control scenarios is being carried out which will be examining the costs of damage caused by SO_2 on the environment. The Convention clearly stresses that there is a need for data collection, evaluation and exchange before any action is taken. However, this process is being accelerated so that all aspects of concern such as materials, aquatic ecosystems, soils, groundwater vegetation and health are being rather rapidly reviewed by Expert Groups for input to the Cost Benefit Analysis Study by December 1982.

The effect of air pollutants on materials is therefore being studied with immediate priority for input to this UNECE Cost/Benefit Study due to the potentially large damage costs incurred in this area. Several Cost/Benefit Studies have been carried out and one recent major investigation is the OECD study on Costs and Benefits of SO_x control (1981). Assessments of damage have been estimated at $2.20 per capita (UNECE 1982); however some studies (Stankunas et al. EPA 1980, Saunders 1982) are indicating that in many cases the damage may have been overestimated. In the long term the importance of these studies will also lie in the prediction of materials' performance in the atmosphere for application to modern engineering design practice.

The current investigation is being focussed on zinc, as it was concluded by the UNECE Materials Expert Group that there was, as yet, insufficient information on other economically important materials, such as paint and stone, to quantify damage. New aspects are being considered, such as the possible existence of a "threshold level" for SO_2 damage to zinc, where at SO_2 levels higher than the threshold, corrosion acceleration above that caused by natural weathering occurs. The Shaw Corrosion Data for the UK (Shaw 1978) - a set of 2000 corrosion measurements for three, 2 year periods - are being used to derive a new dose response function/or functions based on these parameters to describe the effects of pollutants on zinc. The main air pollutant being investigated is SO_2. This stems from the circumstance that SO_2, in many studies, is the only pollutant measured. The effect of other pollutants such as Carbonyl Sulphide (COS), Nitrogen Oxides (NO_x), rain acidity or particulates, have not been so widely investigated although there appears to be little evidence of damage to zinc from Nitrogen Oxides.

---

* UNECE - United Nations Economic Commission for Europe

DOSE RESPONSE FUNCTIONS

The deterioration of materials in the atmosphere is well known and common manifestations are rusting, paint flaking, and erosion of statues such as those on St. Paul's or the Chariatyds in the Temple of Erecthion on the Acropolis. Atmospheric corrosion processes are extremely complex, involving both meteorological and pollutant variables. Corrosion will occur under normal weathering conditions as a natural process and it is therefore necessary to separate this naturally occurring corrosion from pollutant accelerated effects in order to make an assessment of damage from air pollutants. The quantification of damage is usually carried out using a function known as a "dose response function" (DR). This is a quantitative expression which sets out the relationship between the deterioration rate of a material and the factors affecting that rate. The derivation of a DR function is not an obvious or simple task as each site where material is exposed to the environment is characterised by the various factors which make up the effective microclimate at that exposure site: including temperature, windspeed, rainfall duration and amount, surrounding topography, relative humidity and air pollutant concentrations. The function can therefore contain a range of parameters and is usually derived by statistical analysis of a set of corrosion data. This method is favoured as the complex interactions of meteorological and pollutant variables have not been elucidated.

Within the area of effects on materials there are many gaps in knowledge, particularly for paint and stone, but zinc is regarded as amenable to damage assessment. It is widely used for transmission towers, barbed wire and other galvanizing applications and has been extensively studied. Attempts to quantify damage from air pollution have rested on several assumptions: that the mechanism of corrosion is well known, that zinc has an easily quantifiable damage parameter (zinc weight loss), and in addition, that the many damage functions available in the literature for zinc (Table 1) suggest that the damage can be readily computed. However, the wide variety of functions available to describe essentially the same corrosion process illustrates the problem of determining which equation, or equations, are valid and suitable for use in a cost benefit study. It is therefore worthwhile to consider briefly some aspects of the corrosion process related to zinc to gain an understanding of the problems involved.

MECHANISM OF ZINC CORROSION

Corrosion of metals is an electrochemical process requiring the presence of a moisture film in order to occur. No corrosion can take place even at high SO_2 levels unless moisture is present. This was first demonstrated by Vernon (1935) who determined the "critical humidity" at which corrosion is appreciable. Under real exposure conditions corrosion is therefore a discontinuous process and many attempts have been made to measure the "time of wetness" (related to % Relative Humidity) as a major parameter in the corrosion process.

The primary products of reaction of zinc with the atmosphere are oxides, hydroxides or carbonates formed at the metal/oxide interface. The reaction with SO_2 occurs at the oxide - atmosphere interface and the conversion of the metal oxide or hydroxide to sulphate is therefore a secondary corrosion product. These overall reactions which involve many reaction steps can be summarised by the following equations.

$$Zn + H_2O + \frac{1}{2} O_2 \qquad Zn(OH)_2$$

$$Zn(OH)_2 + SO_4^{=} \qquad Zn\ SO_4 + 2OH^-$$

In fact a range of basic sulphates is formed ($Zn\ SO_4 . X\ Zn(OH)_2$) depending on the amount of SO_2 available; these have varying degrees of water solubility and are washed from the surface by rain. The initial thickness of the corrosion product layer must then be re-established by primary hydroxide (carbonate or oxide) formation.

The role of moisture, represented by relative humidity, is therefore in governing the absorption of SO_2 from the atmosphere by the zinc surface and in the reaction of the zinc, and zinc products, to form the hydroxide and the sulphate respectively. Progressive dissolution of the protective oxide or hydroxide on the zinc to soluble zinc sulphates at high SO_2 concentrations can lead eventually to direct reaction with the zinc to form sulphates.

There are several consequences to this mechanism. The obvious major parameters affecting corrosion rates are moisture (expressed as RH or time of wetness), pollutant concentration, possibly temperature and the delivery of the pollutant to the surface (windspeed).

THRESHOLD LEVEL

From the mechanism of the corrosion process described above, conversion to sulphate must be sufficient to cause either thinning or breakdown of the protective film on the metal for accelerated corrosion to occur. It is therefore possible that a threshold level does exist for damage. Considering some data from atmospheric corrosion surveys Figure 1 shows that below 40 ug/m^3 there is almost no variation in the corrosion rate with SO_2 level.

In addition the time of wetness may also have a threshold effect and at low SO_2 levels high corrosion rates can result. Norwegian data (Atteraas et al. 1980) and early work by Ellis (1959) indicate that for initial exposure of zinc the period of wetness does have a major effect on the final corrosion rate. The literature is confused on this problem, which Barton first raised in 1973. Benarie (1980) reviewed the literature and concluded that a threshold level could exist. To resolve this problem a controlled parameter study in an exposure chamber has been initiated at UMIST and some results will be available shortly.

AVAILABLE ZINC DAMAGE FUNCTIONS

In order to determine whether any of the existing dose response (DR) functions are valid for use in a cost benefit study and how they compare with the derivation of the zinc function for the UK, a critical evaluation of the various studies listed in Table 1 has been made (Brownfield and Saunders 1982). Although no survey can be completely free from criticism, as resources will limit the scope of any study, some of the problems encountered can be briefly summarised. These include

(i) inadequate data bases.
(ii) general use of equations originally derived on limited data. For example the Guttman (1968) equation was originally derived for one site and this limitation is clearly stated by the author. However it has been used in the OECD study.
(iii) a strict enforcement of statistical criteria without relation to the corrosion process. This is illustrated by the Haynie and Upham 1970 equation which, although based on an excellent survey, is constrained to go through the origin when it is known that even at low SO_2 levels, corrosion still occurs from the other atmospheric factors present.

(iv) none of the equations takes a threshold level for damage into account.

Theoretically there should be only one equation to describe the corrosion process which would probably have many parameters and could be applied universally. However for practical application most functions are limited and therefore the extent of their application must also be determined.

The problem is therefore whether any of the existing functions describes the corrosion process in a form suitable for use in a cost benefit analysis of SO_2 emission control, and how they compare with the functions being derived for the UK, based on the Shaw Corrosion Data.

REGRESSION ANALYSIS

The technique employed to derive a DR function is the standard statistical method of regression analysis. Basically regression analysis is a technique for estimating the extent to which changes in the value of a dependent variable, "Corrosion Rate", are related to change in independent variables, "Corrosion Rate", are related to changes in independent variables, "SO_2", "RH". The expression Corrosion Rate $= K + {}^{a}\ SO_2 + {}^{b}\ RH$ is called the regression equation and a, and b, are regression coefficients. It is usually obtained by a least-squares technique which generates a "best" line minimising the sum of the squares of the deviations between observed and predicted values.

DR FUNCTION FOR COST BENEFIT ANALYSIS

The main problem with functions available in the literature is that they were derived for engineering applications and in many cases are quite satisfactory for this particular purpose; however they are not suitable for providing an unbiased estimate of the contribution of SO_2 to corrosion.

The reason for this lies in the statistics used in the derivation of the function. In the engineering approach the functions have been designed to explain as much of the corrosion rate as possible with a minimum number of usable variables by choosing only the most significant. If two variables are strongly correlated, one may be used alone and its coefficient will describe the combined effects of each of the 2 original variables via the correlation. This bias in the coefficient is not a problem from the engineering viewpoint and within the limitations of the regression such an equation can be used to predict corrosion rates for materials applications. However this approach cannot be applied in order for the function to be used in the cost benefit analysis of SO_2 control. If any variables affecting the corrosion rate are missing from the regression, and if these are correlated with SO_2, then the coefficeint on SO_2 will be biased by the extent of that intercorrelation.

All explanatory variables that are significantly correlated with SO_2 must remain in the equation specification. The emphasis therefore is on providing an unbiased estimate rather than maximising total explanatory power. To illustrate this the UK was divided into four broad areas and a simple regression on SO_2 alone was performed. The coefficient for SO_2 was tested for variation from area to area and the results are shown in Figure 2. This shows that there are regional differences involved in the corrosion process, and a simple equation in SO_2 will have a biased coefficient accounting for these differences.

Although it is difficult to compare different functions on a statistical basis, some of the functions were fitted to the UK data base. The OECD equation, plotted against the UK data base, gave a low correlation coefficient of 0.37.

COMPARISON WITH OECD STUDY

We have the problem, of course, that the OECD Costs and

Benefits of SO_x control tried to perform a similar selection of a function simply by graphing 2 functions and 2 data sets, making the assumption that a simple linear regression line in one variable, SO_2, fitted to this data base, was sufficient to describe the zinc corrosion behaviour for the whole OECD region (Figure 4). The two sets of data are

(i) Swedish Data consisting of 2 data points joined by a line
and
(ii) 1953 UK Hudson and Stanners data from 9 points with SO_2 absorption data converted to volumetric units by the 1968 Guttman function. Unfortunately this procedure is not valid as only specific measurements by both methods at a particular site can be used to convert one measurement to another.

No information on climatic factors is given and the assumption is made that all places in the ECE region are equally wet. The two functions are the Guttman Equation 1968, derived specifically for one site, as mentioned earlier, and the Haynie and Upham 1970 equation, which unfortunately goes through the origin. Another assumption that these sets of data represent the true spread of data available is then made and the Hudson and Stanners equation taken as the mean. It can therefore be seen that, as an initial attempt, the OECD study points the way but is subject to the major limitation of providing only a biased assessment of the SO_2 contribution to corrosion. In addition the data base is selective and inappropriate particularly as other, better, data are available in the literature, given the limitations already described.

UK ZINC DOSE RESPONSE FUNCTION

There are two main aspects to the derivation of a UK Zinc DR function. The first is to derive a function with an unbiased estimate for the coefficient on SO_2 for use in a cost benefit analysis evaluating in the process the relative importance of meteorological variables on the total corrosion rate. As part of the analysis it is also proposed to derive an 'engineering type' of equation for general use.

One aspect of this type of study, which it is hoped will be particularly useful, will be the final output in terms of a corrosion contour map, based on the DR function for the UK, which can be used to attribute damage more accurately to the actual "stock at risk" distribution in the cost benefit study. A similar map based on an engineering equation may also be used for other purposes including engineering material selection applications.

DATASET

We have been fortunate to have available in the UK the most comprehensive corrosion data base in the world. This is the Shaw Corrosion Data which was compiled from 3 sets of 2 year averages of zinc rates for 2195 sites with meteorological data measured at 165 sites and SO_2 data measured at 172 sites. As a comparison, the data bases considered in other surveys comprised about 10 sites with a range from 8-57 sites for a given time period. Figure 2 shows the distribution of sites within the UK. The size of the data base means that a large number of variables, which have never before been investigated, may be examined. Details of the dataset compiled and variables involved are given in Tables 2 and 3.

To reach the stage of performing a statistical analysis, many problems had to be overcome in taking account of the errors in original data, missing data, transformations of meteorological data to sea level before interpolation and compilation of data from maps. In the statistical analysis a major problem has been the interdependence of variables. For example, duration of rainfall is strongly correlated with amount of rainfall. Scatter plots were generated to check for normal distributions of the data. Figure 3 shows the scatter plot for corrosion rate and SO_2 for 3 x 100 Km^2 areas.

Not all the corrosion measurements have meteorological or pollution data associated with them, and to take advantage of the full scope of the corrosion data available a complex interpolation surface fitting programme was devised to interpolate meteorological and pollution parameters at the other sites. To test the surface fitting technique for the pollution data, contour maps were derived on a 1:100000 scale for comparison with Warren Spring Laboratory (WSL) maps drawn from measurements and interpolated on the basis of experience and other data inputs. Figure 4 shows the derived contours and good agreement was obtained with the WSL map. Similarly meteorological parameters were predicted and compared with measured values.

FORM OF THE VARIABLES

The influence of diverse variables is not necessarily straightforward. For example rain will increase the wetness time, and increase corrosion, but in large amounts will wash away pollutants, thus decreasing corrosion. Very large amounts of rain can also erode the protective oxides and carbonates, producing an increase in corrosion rates. A cubic function in duration of rainfall, amount and intensity was therefore included and tested to try to capture this effect. The form of each variable has been considered as far as possible, and combined variables have been derived and used such as $SO_2 \times RH$, which will try to take account of some of the interactive behaviour of these variables.

FORM OF THE EQUATION

The functional form of the equation was tested using linear, parabalic, logarithmic and squared functions of Rate. The Knotkovan-Cermakova (1974) functional form was also investigated. However, the results showed that there was no obvious gain in using the complex functions, therefore the linear function was chosen to preserve simplicity. A plot of the residual (OBSERVED-ESTIMATED) values against the estimated corrosion rate confirmed that the linear case was reasonably balanced.

REGRESSION ANALYSIS

Using a master file set up from measured and interpolated values, and excluding coastal sites, the analysis was carried out in several stages and initially only the first time period 1969-71 has been used. The first step is to eliminate variables from the large selection available. This is carried out by inclusion initially of SO_2 and all variables correlated with SO_2 whatever their apparent significance, as any other procedure would result in biased coefficients for SO_2. It is also important to leave other significant, but SO_2-uncorrelated variables, in the analysis because the change in benefits due to SO_2 will depend on the estimate of total rate. Contrary to the engineering approach, uncorrelated significant variables may be set equal to their mean and included as a constant. This allows the original complex regression equation to be simplified for use in the CBA. Element analysis, a specific statistical technique, was also used to analyse the interactions between variables as their true importance is masked by high interdependence in ordinary regression analysis. Element analysis shows that some terms such as RH90 and $SO_2 \times RH90$ have a very high secondary interaction term, and one would normally be dropped from the equation, but both also interact with SO_2 and are therefore retained. The final set of variables is given in Table 4 and the regression equation using these variables will be discussed at the conference and published in Part II of the Proceedings.

TABLE 4

FINAL REGRESSION VARIABLES

D SO_2I RH90 TEMP WS I^2 SR90 SO_2I SO_2T

PAINT

In the case of paint the problems associated with a damage function derivation are enormous. There is no unequivocal method of determining a damage parameter for paint. Film thickness has been used but variations in this parameter are by no means necessarily caused by SO_2 effects. Most studies in paint have been carried out at unrealistically high SO_2 levels where the mechanism of attack is probably very different from low levels of SO_2 attack, if there is any at all. There are a myriad of paint types such as latex, oil-based and resin-based paints, a large range of formulations and of carrier, pigment, and solvent which will affect protective behaviour, and its response to SO_2 concentrations. There is no information on the existence of threshold levels for SO_2 damage on paint and the effect of other pollutants such as H_2S, or particulates and moisture effects, are thought to be of major importance but have never been quantified.

As a consequence of the complexity of paint films and their deterioration mechanisms, investigations of paint behaviour have been restricted mainly to comparative studies. This method is only suitable where the length of life of a particular paint in an "urban" area is compared to that in a "rural" area and recommendations on maintenance painting or suitability of paint type can be made. However when attributing damage to particular sources such as pollutants, we have the familiar problems of deriving an unbiased estimate for SO_2 for use in a cost benefit analysis, and even more importantly of identifying true cause and effect relationships between pollutants (particulates, SO_2, NO_x) and paints. It is important therefore that any measured damage can be attributed to the correct factors and not those by chance conveniently measured. Due regard to known deterioration mechanisms is essential, and therefore simple linear functions in SO_2, based on comparative studies with no cause and effect demonstrated, or other pollutants measured, is unacceptable. This unscientific approach has already been adopted by the OECD where the analyses have been performed on an unspecified paint, with lifetimes attributed from Inland Revenue Tables for amortisation of tax for pre 1970 conditions correlated to unrelated average air quality measurements.

Some chamber studies have been carried out, however, and the available derived functions, although restricted, are listed in Table 5.

STONE

There is no reliable damage function for stone as yet. Corrosion studies are currently under way by NATO CCMS*, CEGB/DOE, and a PhD study under contract from the Building Research Establishment (BRE). All these studies use susceptible limestones or calcareous sandstone and are designed to measure the conversion of the stone to sulphate and subsequent weight loss. Again, however, the problems of a competent damage parameter arise with stone, as both pollutant and meteorological parameters affect the physical and chemical damage to the stone. The original stone structure and porosity are key factors in the extent of damage, and other pollutant contributions - particularly from nitrogen oxides - have barely been studied. There are many problems even with current studies and it will be some time before a convincing DR function will be derived. Available information on functions and their origin is summarised in Table 6.

CURRENT CORROSION SURVEYS

SMALL SCALE SURVEY

As mentioned above, a joint CEGB/DoE experimental type of survey is currently underway to investigate methods of damage measurement on selected metals, candidate paint systems, and on stone. The results will be associated with comprehensive pollutant measurements, though of course no functions will be able to be derived from the data from only 8 sites. The details of the survey are listed in Table 7.

The Candidate paint systems which have been selected will have 5 different damage measurements. In addition the effect of the metal substrate will be investigated. Time of wetness measurements using the Sereda wetness meter are incorporated and it is hoped the importance of this parameter for these materials can be established.

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*CCMS Committee for the Challenges to Modern Society.

LITTLEHAMPTON SURVEY

The CEGB is currently investigating the effect of pollutants on crops in the ambient environment and, at the site at Littlehampton, four separate SO_2 and NO_2 levels are available at four plots within a one acre field. The pollutant levels are delivered by a complex array of nozzles, designed to maintain a constant composition at the crop canopy height, and a feedback measuring mechanism run by a minicomputer is used to control the system. A series of corrosion specimens, similar to those exposed in the small survey, will be exposed. Specific SO_2 measurements will be made at the sample racks located within each plot, having average target compositions of 5ppb (background), 20, 40 and 60 ppb SO_2. Wetness measurements will also be made.

With this survey it is expected that, due to the proximity of the exposure racks within the field, the meteorological conditions in general can be taken as constant, and any variations observed attributed directly to pollutant effects. Although other studies have suggested that similar conditions prevail, this is the first study with a series of controlled pollutant levels in such close proximity where rainfall, temperature, windspeed and other factors will be constant across the field.

LARGE SURVEY

To update the Shaw Corrosion data and investigate functions for paint and stone it is proposed that a large survey for the UK be undertaken with the probable starting date April 1983. The problems of site selection and parameter measurement are being discussed currently and some details are given in Table 7.

SUMMARY

For materials it will be some time before sufficient reliable data are available to quantify damage to all systems. For zinc, this may be possible as a first stage using the new UK function as the first unbiased estimate of the effect of SO_2. For the UK, the Shaw Corrosion data will also allow investigation of regional variations and threshold levels. The development of a corrosion contour map output based on the CBA function will allow a more accurate economic assessment to be made, based on the distribution of stock at risk and, based on an engineering function, will allow more accurate material lifetime predictions to be made for engineering design applications.

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TABLE 1 DAMAGE FUNCTIONS FOR ZINC AND GALVANIZED STEEL

REFERENCE	EQUATION	PARAMETERS
Barton 1980 10yr extrapolation ZINC	$K = 0.00076t_w^{0.50}SO_2^{0.718}$ $K^1 = 1.4t_w^{0.51}SO_2^{0.72}$	t_w= total time RH 80%0°C in terms of hrs/day calc. from linear reg. averages. SO_2 daily averages (4xday 1xweek) K = CORR LOSS OR RATE $g/m^2/day$
Haynie & Upham 1970 ZINC	$K = 0.001028(RH-48.8)SO_2$	Ave SO_2 K = CORR RATE = um/exposure time
Guttman 1968 ZINC	$K = 0.005461(t_w)^{0.8152}(SO_2+0.02889)$	t_w= time of wetness (hr.) SO_2 when panels wet (ppm) K = CORR LOSS/3 x 5" panel
Nordforsk 1975 ZINC	$K = 0.22SO_2 + 6.0$ $K = 0.27Cl + 0.22SO_2 + 4.5$	CORR RATE $g/m^2/y$ SO_2 ug/m^3 Cl^- $g/m^2/y$
Haagenrud et al. 1980 ZINC	$K = 0.03SO_2 + 0.01RH\ 90 + 1.6$ $K^1 = 0.06SO_2 - 0.14T + 2.3$	K = MONTHLY CORR RATE g/m^2 SO_2 ug/m^3 RH 90 time in hrs. when RH 90% per month K^1= monthly corr rate g/m^2 SO_2 ug/m^3 T monthly mean Temperature
Hudson & Stanners 1953 ZINC	$y = 6.32 + 0.159\ SO_2$	Calculated regression for 9 sites $y = g/m^2$ $SO_2 = ug/m^3$

TABLE 1 continued

COMPARISON OF FUNCTIONS

REFERENCE	EQUATION	PARAMETERS
MICHAILOVSKII 1980 ZINC	$Kg/m^2/y = [(2.0 \times 10^{-4} + 2.0 \times 10^{-4} T)t_w + (5.5 \times 10^{-2})(SO_2)] g/m^2/y$	K = TOTAL CORR RATE $g/m^2/y$ T temperature A CORR Rate under atmos conditions B CORR Rate under SO_2 SO_2 ug/m^3 t_w time of wetness hrs/y $= \frac{tRH80\%}{2}$ at -2.5 t +27.5°C
NORWEGIAN FUNCTION FOR ECONOMIC ASSESSMENT	$y = 0.45SO_2 + 0.7$	SO_2 ug/m^3
Galvanised Steel Henriksen et al 1979		$y = g/m^2/y$
OECD ZINC	$y = 0.204(SO_2) + 2.46$	SO_2 ug/m^3 $y = g/m^2/y$
GUTTMAN & SEREDA 1968 ZINC	(Cleveland) Site $y = -0.0000205 t_w^{0.96095} (T-294.765)$ (Ottawa) $y = 0.037(t_w)0.87681 (SO_2 + 0.17027)$	t_w = time of wetness (damp) T = temperature (°F) y = corrosion loss (g) SO_2 in ppm

TABLE 1 continued

COMPARISON OF FUNCTIONS CONT.

REFERENCE	EQUATION	PARAMETERS
KNOTKOVA 1974 ZINC	$K = \; {}_{0}{}^{RH} \quad {}^{1} \quad 2\,T + \quad 3\;{}^{SO_2}$	Ave Temp T V freq of occ of RH 80% SO_2 as ave daily dose $mg/m^2/day$
HAKKARAINEN 1980 ZINC	$K = 0.0049t_w^{0.91}(SO_2 + 0.05)$	t_w time RH 85% SO_2 ug/m^3 K = CORR rate um/y
HAYNIE ETAL 1976 GALVANISED STEEL	$K = (0.0187SO)_2 + {}^{41.85-23.24/RT})t_w$	K = CORR LOSS t_w = wetness time SO_2 ug/m^3 T = temperature R = Gas constant
BARTON 1978 ZINC	$K^1 = 3.161 \times 1\bar{0}^4(H_2O)^{0.822}(SO_2)^{0.766}$	$K = mg/m^2/day$ $(H_2O) =$ hrs/day when RH 80% $(SO_2) = mgSO_2/m^2/day$
MANSFELD 1980	$\log V(t) = 1.977 - 0.144 \log t$ $\log V(t) = 1.863 - 0.102 \log t + 0.004TS - 0.005SO_2$ $+ 0.0054H_2S - 0.65O_3 - 0.002NO_x + 0.003TSP$ $- 0.008SO_4 + 0.018NO_3$	Vt = Corrosion rate t = exposure time TSP= total suspended particulate TS = total sulphur SO_2, H_2S, O_3, NO_x, SO_4^-, NO_3^-

TABLE 2

DATASET

2383 OBS 1969-73
1311 OBS 1969-71

CORROSION SITES

EACH SITE (2195) EAST NORT ZINC LOSS DATES EXPOSED, RETRIEVED
ALTITUDE DIST OF SEA

METEOROLOGICAL VARIABLES

TOTAL MEAN MONTHLY RAINFALL
MEAN MONTHLY WINDSPEED (HOURLY DATA)
TOTAL NO. HRS/MONTH RH 80
TOTAL NO. HRS/MONTH RH 90
MEAN TEMPERATURES

POLLUTION VARIABLES

SO_2 AVERAGED OVER 2 YEAR PERIOD OF EXPOSURE
SO_2 WEIGHTED AVERAGE OF 6 MONTHLY SUMMER AND WINTER MEANS

TABLE 3

REGRESSION VARIABLES

SO_2I	WEIGHTED AVERAGE (AVE.) SO_2 FOR 1st 6 MONTHS OF EXPOSURE ug/m^3
SO_2A	AVE. SO_2 OVER 2 YEAR EXPOSURE PERIOD
$SO_2{}^2$	
RH80	NO HRS/PER MONTH RH 80 FOR EXPOSURE PERIOD
RH90	NO HRS/PER MONTH RH 90 FOR EXPOSURE PERIOD
A A^2 A^3	AMOUNT OF RAINFALL (0.1 mm) AVE. TOTAL MONTHLY
D D^2 D^3	DURATION OF RAINFALL AVE. YEARLY MEAN
I I^2 I^3	INTENSITY OF RAINFALL $I = A/D$
AI AI^2 A^2I	
AD AD^2 A^2D	
WS (LNWS)	WINDSPEED (cm/s) AVE. MONTHLY MEAN
DR1 (LDR1)	AVE. WS X A
SR90	$SO_2 \times RH90$
ASO_2	$SO_2 \times A$
ISO_2	$SO_2 \times I$
DSO_2	$SO_2 \times D$
S WIN	$SO_x \times WS$
SO_2T	$SO_2 \times T$
RATE	CORROSION RATE $g/m^2/y$

OTHER VARIABLES IN DATASET

Fsea	DISTANCE FROM SEA
EAST	GRID REF. NUMBER EASTING
NORT	GRID REF. NUMBER NORTHING
YEAR	DATES OF EXPOSURE AND RETRIEVAL

TABLE 5

PAINT DAMAGE FUNCTIONS

Haynie et al 1976

Laboratory study

1. Oil base house paint on Aluminium	$y=14.3+0.0151SO_2+0.388H$	y um/y SO_2 ug/m^3 H RH%

Other conclusions

NO_2 increased the weight of the film

O_3 was not significant

2. Vinyl coil coated paint	$y=2.51+1.6\ 10^{-5}(SO_2)(H)$
3. Acrylic coatings	$y=0.159+0.000714O_3$

Mansfeld 1980

Exposure study	Mayor Parameters	
1. Latex base house paint stainless steel substrate	NO_3 TSP SO_4 (negative effect) O_3 accelerated corrosion TSP = Total Suspended particulates	$\log y=1.678-0.04\ NO_3$ wt loss mg/y NO_3 ppb
2. Oilbased Paint	time of exposure SO_4	$\log y = 1.263-0.098 \log t +0.021\ SO_4$

OECD 1981

By comparative method	$L_1 = 11.6 - 0.016\ (SO_2)$	Painted Steel	(from Fink et al 1971)
	$L_2 = 15.6 - 0.031\ (SO_2)$	Painted Galvanised Steel	

TABLE 6

STONE DAMAGE FUNCTIONS

Sengupta and de Gast (1972) Laboratory study (78)	Sulphate formed (g) = 0.05 (porosity) + 0.07 (permeability) + 0.04 (water absorption) + 0.07 (Calcite/Dolomite) + 0.32	
Haynie Spence and Upham 1976 Laboratory study (20)	$y = 3.31+0.78H + 2.95.10^{-3}SO_2+3.33.10^{-3}O_3$	y = um/y H = RH% SO_2 ug/m^3 O_3 ug/m^3
Luckat (1981) Outdoor exposure study (75)	Baumberger calciferous sandstone $U = 0.54\ D\ (r^2 = 0.92)$ $L = 0.03\ D + 0.5\ (r^2 = 0.36)$	U = SO_2 uptake by rain-sheltered, omnilaterally exposed stone during one year's exposure (mg SO_2/m^2d)
	Krensheimer shell limestone $U = 0.22\ D\ (r^2 = 0.72)$ $L = 0.018\ D + 0.6\ (r^2 = 0.8)$	D = dry deposition of SO_2 measured by IRMA absorption method, yearly average (mg SO_2/m^2d) L = weight loss of nonsheltered, omnilaterally exposed stone after one year's exposure (%) r^2= correlation coefficient

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measurement of stone samples 60 x 60 x 3 mm

Small Scale Survey					Damage Measurements
8 sites	3 Paint Systems:	Primer	Substrates:	Steel	Adhesion
South East		chlor rubber		Galvanised steel	WT Loss
& Midlands		alkyd		Stainless Steel	Film Thickness
				Glass	Reflectance
					Visual Inspection
	5 Metals:	Zinc Can			
		Galvanised Steel			
		Mild Steel			
		Stainless Steel			
		Weathering Steel			
	4 Building Materials:	Monks Park Limestone			(WT Loss
		Portland Limestone			(Conversion to $SO_4 = NO_3^-$ or Cl^-
					(Penetration depths of SO_x, NO_x, Cl^-
		Concrete			(Dimension changes
					(Loss of alkalinity from CO_2
					(Penetration of SO_2 Cl^-,^{2} CO_2
					(Surface Roughness

Pollutant Measurements

Most Sites: Continuous SO_2 NO NO_2 CH_4 Rain Analysis, Particulates
Others : HCl, O_3

Meteorological Measurements

Most Sites: t_w (sereda wetness meter) temperature, windspeed, wind direction
Others : Rain amount and duration, continuous RH measurements.

Extended Survey

50 Sites	Zinc can	Meteorological Measurements
	Paint	Pollution
	Stone	Wetness

TABLE 7

FIGURE 1

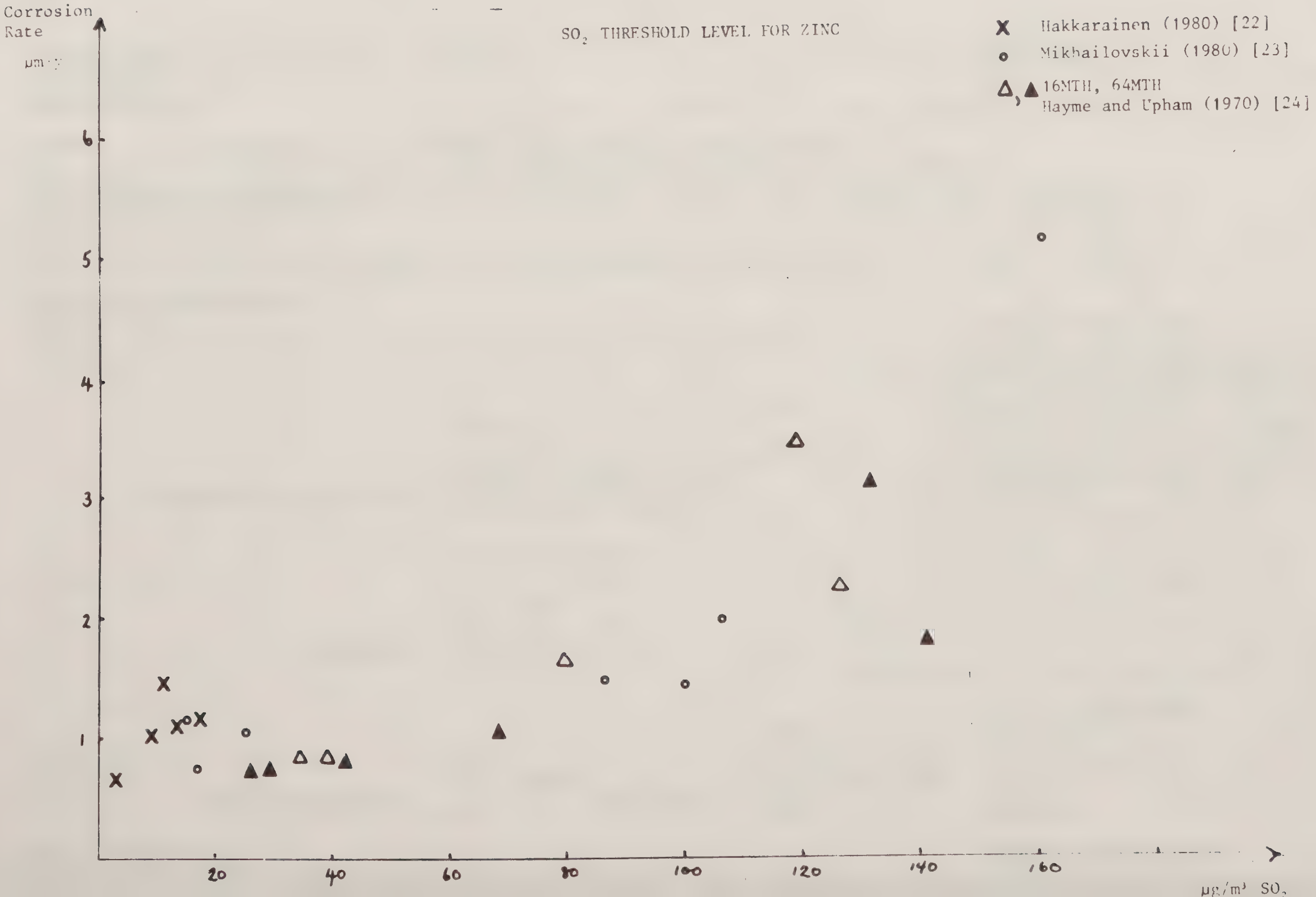
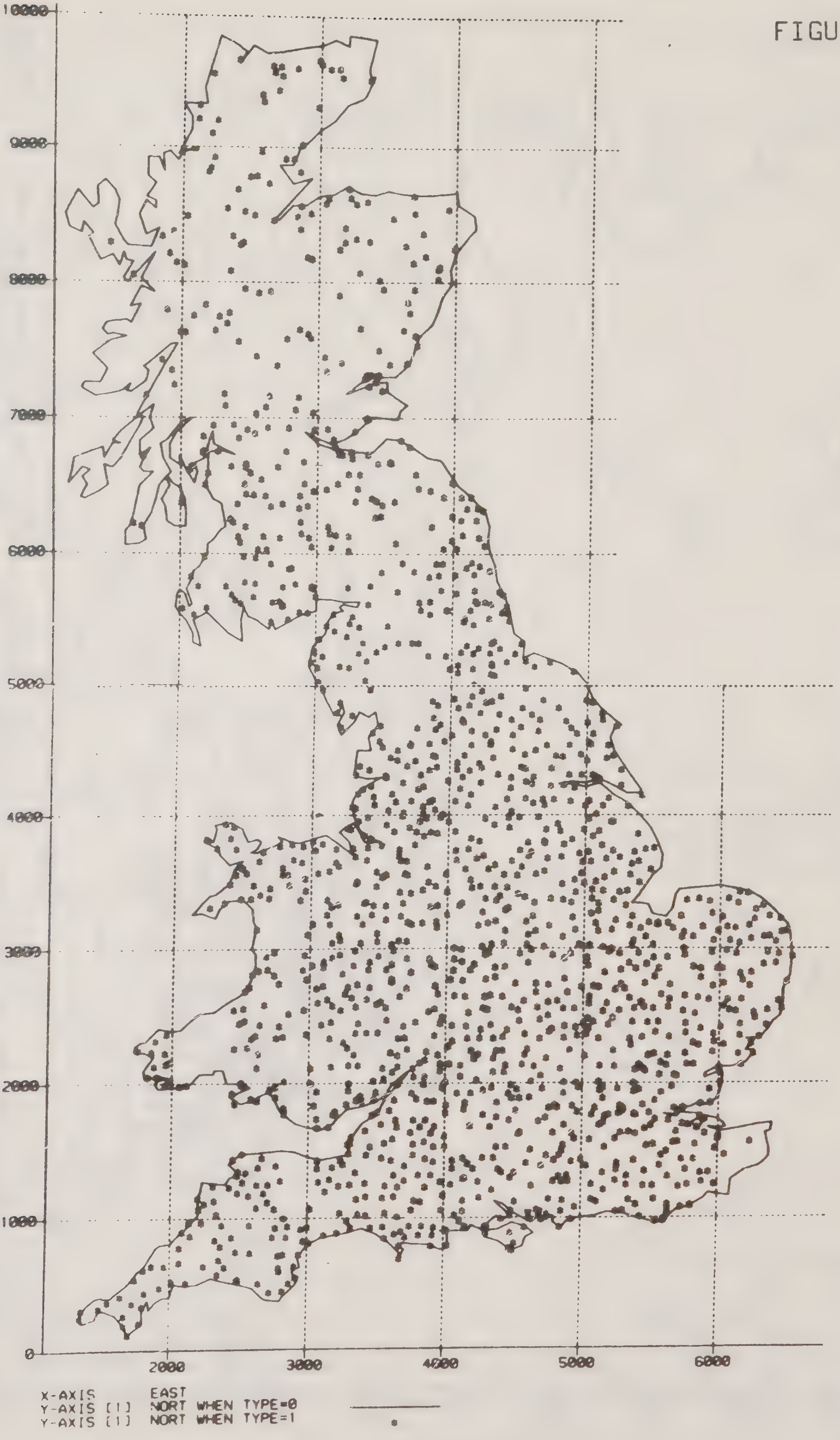

SO$_2$ THRESHOLD LEVEL FOR ZINC
Corrosion Rate
µm·y
6
5
4
3
2
1
20
40
60
80
100
120
140
160
µg/m³ SO$_2$
X Hakkarainen (1980) [22]
○ Mikhailovskii (1980) [23]
△, ▲ 16MTH, 64MTH
Hayme and Upham (1970) [24]

FIGURE 2


10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2000
3000
4000
5000
6000
X-AXIS EAST
Y-AXIS [1] NORT WHEN TYPE=0
Y-AXIS [1] NORT WHEN TYPE=1

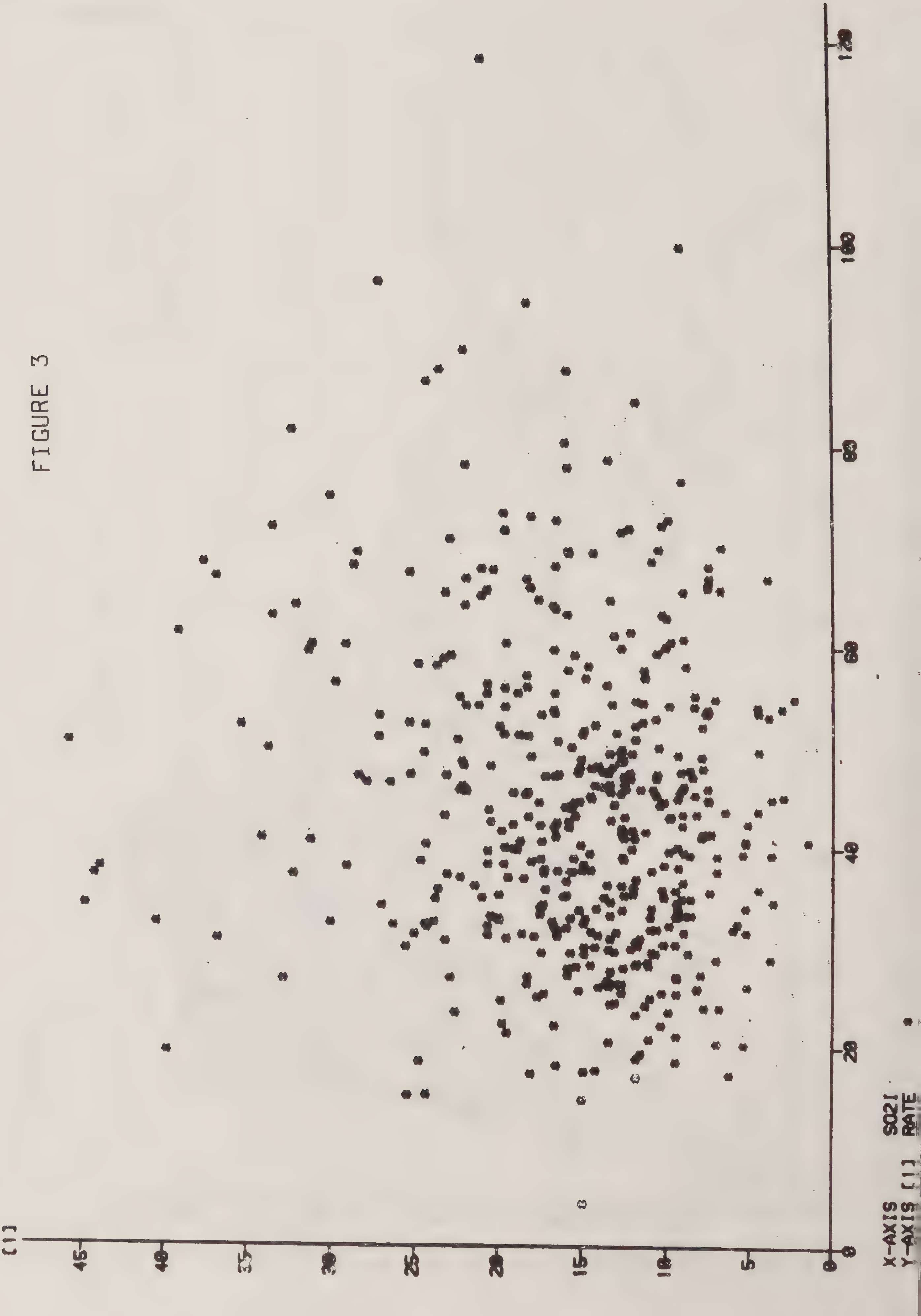
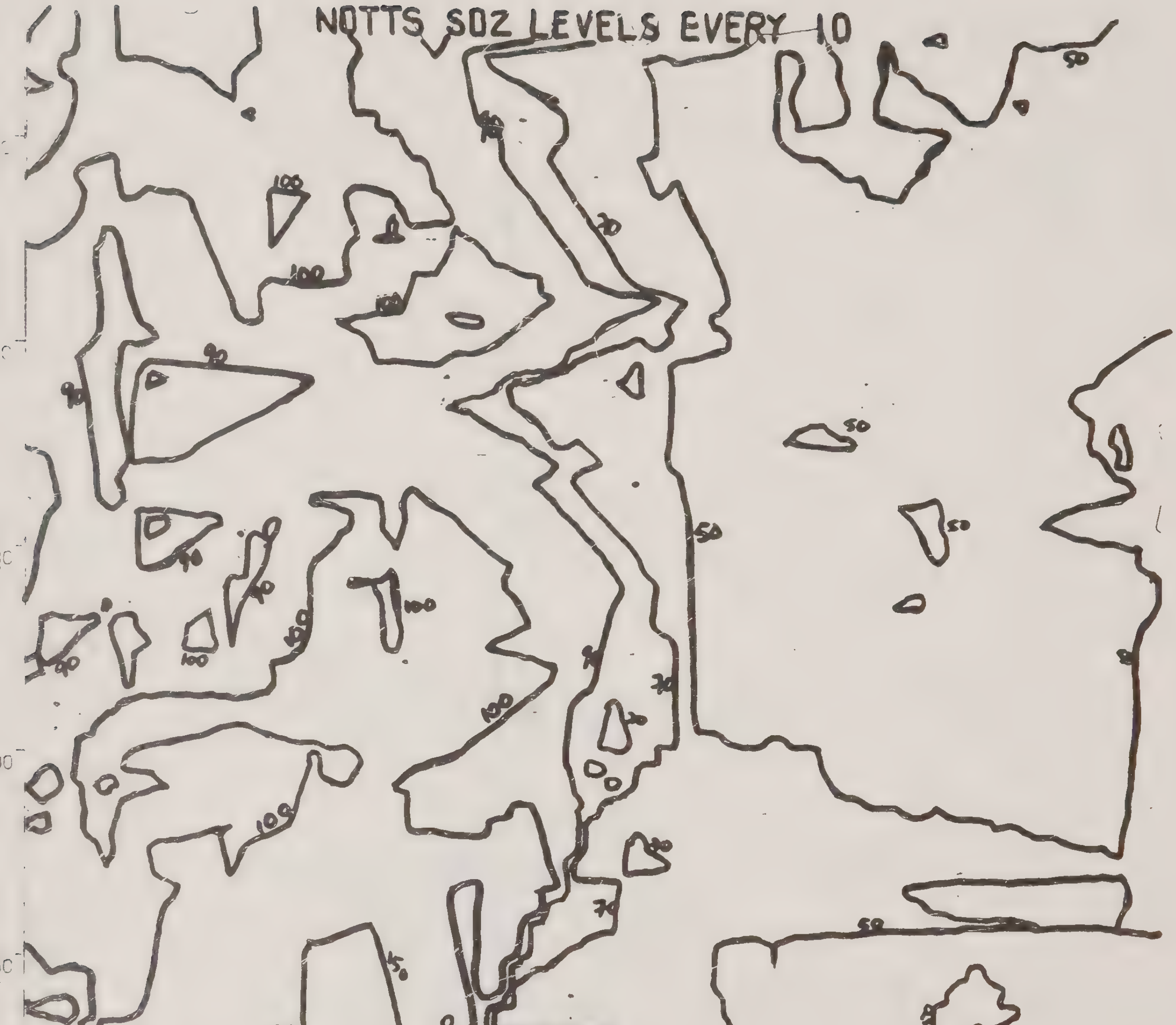

[1]
0
5
10
15
20
25
30
35
40
45
0
20
40
60
80
100
120
X-AXIS SO2I
Y-AXIS [1] RATE

FIGURE 3

FIGURE 4


NOTTS SO2 LEVELS EVERY 10
50
70
100
100
100
90
90
50
50
90
100
150
100
90
70
70
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70
50
150
150
100
90
NOTTINGHAM.
100
90
70
90
90
70
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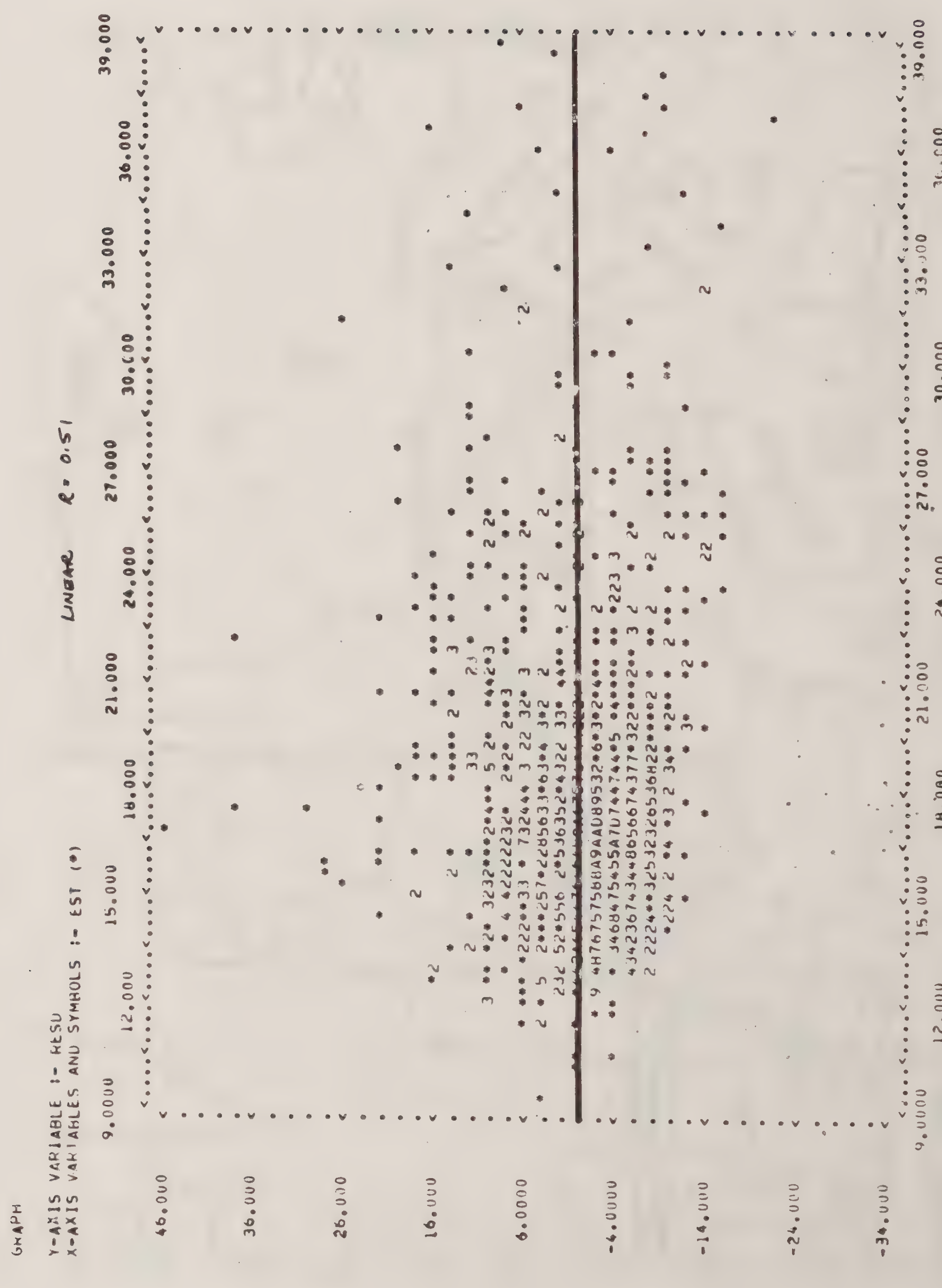
50
70
70
50
50
50
4500
4900

FIGURE 5


GRAPH
Y-AXIS VARIABLE :- RESU
X-AXIS VARIABLES AND SYMBOLS :- EST (*)
LINEAR R = 0.51
9.0000
12.000
15.000
18.000
21.000
24.000
27.000
30.000
33.000
36.000
39.000
46.000
36.000
26.000
16.000
6.0000
-4.0000
-14.000
-24.000
-34.000

nsca
49th ANNUAL CONFERENCE
21 OCTOBER 1982
LLANDUDNO

AIR POLLUTION CREATED BY AGRICULTURE – THE NEED FOR CONTROL

By

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INTRODUCTION

District Councils with large rural communities have over the years taken a responsible and realistic attitude to farming problems, even though the farming community is no longer the largest lobby of rural lifestyle. Over the past few years the urban and industrial town dwellers have become more inter-related with rural activities and many thousands now live in the countryside.

Many have discovered that living in the country is not the sweet, quiet, idyllic lifestyle they have been led to believe. The often appalling smell associated with the spreading of pig slurry and human sludge can no longer be regarded as a fresh country smell.

Consequently, the rural commuter tends to be less than sympathetic towards industrial farming problems. The National Farmers' Union has expressed concern that the law draws no distinction between the circumstances of the farmer, who finds himself in difficulties because new residential development is permitted close to his existing livestock units and the one who chooses to develop a new unit close to existing houses. To argue that there should be preferential legal consideration in such cases would be contrary to the basic common law principle, that, "a person has a right to the enjoyment of his land regardless of neighbouring development". Any infringement of that enjoyment can be considered a nuisance. Who came first cannot lawfully be considered. However, in the main, the farming industry acts responsibly, but where problems do arise, they often give rise to serious nuisance. There is no doubt that some agricultural practices have materially increased the risk of pollution, not only in the place where they are applied but also where some of the materials are manufactured.

This Paper attempts to deal with the type of agricultural problem encountered by the Local District Councils' Environmental Health Departments and we go on to point out the necessity for new legislation to control certain unsatisfactory practices that are developing.

ODOUR NUISANCE

1. There are approximately 300,000 agricultural holdings (farms, pig units, poultry houses, etc.) in this country. Some smell objectionable all the time, some never cause offence, but the greater number of those engaged in animal husbandry provoke unfavourable comments at some time or another.

2. The majority of odour nuisances from agriculture are related to the production and disposal of animal slurry and human sludge. It is a particularly emotive and outstanding problem. In certain areas of the U.K. the movement and use of slurry and sludge throughout the countryside is increasing but, correspondingly, the toleration of the country residents and travelling public is decreasing and their complaints are becoming more vociferous.

The Institution of Environmental Health Officers carried out an Agricultural Odour Survey in 1980-81. The total number of local authorities circulated was 428 and 313 questionnaires were returned. (73% response).

England, Wales and Northern Ireland were divided into sixteen areas and the Table below shows the result of that survey.

Type of Nuisance (All areas)		Total
No. of Complaints from Animal Housing	Cattle, Sheep, Pigs, Poultry	968
No. of Complaints from Slurry/Manure Storage	Cattle, Sheep, Pigs, Poultry	1086
No. of Complaints arising from land spreading of Slurry/ Sludge Manure	Animal and Human Waste	1774
	Total	3828

There was also a total of 13 prosecutions from Odour Nuisance during the same period.

The survey showed that the worst areas for complaint were, Yorkshire, Humberside and Cleveland (728), Norfolk, Suffolk and Cambridgeshire (531) and Essex, Hertfordshire and Bedfordshire (576).

The Report of the Working Party on the suppression of odours from offensive and selected other trades states that "farm odours have no known effect on the health of the individual, but reactions to them are undoubtedly real and can cause distress and above all a negation of leisure in the accepted English sense. There is also the point that some methods of distribution of animal manures, particularly liquid manure, might conceivably involve the spread of animal or human pathogens with the manure".

In many parts of the country farmers have responded to Local Authority requests to improve their methods of disposal but, unfortunately, the application of animal slurry and human sludge to land in a nuisance-free manner is still high on the list.

We wish to emphasise this point amongst other things in this Paper.

ANIMAL SLURRY TO LAND

Over the past few years, economic pressures and cries for cheaper food have created a firmly established trend to "confinement feeding of livestock". Intensive housing units and many more mixed type farms are moving towards this specialised production with increasing numbers of animals kept per production unit. Market advantages have led to specialisation and concentration of animal production.

Throughout the country, the livestock industry is facing the prospect of adjusting to these shifts and to the amenity protection problems associated with intensive production of livestock.

Pigs consist of about 25% of the national livestock but it is interesting to note that these pigs are housed in approximately 7½% of livestock holdings.

The development of intensive farming has altered the complementary relationship between crop and livestock production. Historically, grain and roughage produced on the land were used for animal rearing while manure from the livestock went back to land for its fertiliser and soil conditioning values. Many intensive livestock units do not produce enough feed on their own land and consequently, the availability of adequate land for spreading their slurry is limited, movement of slurry throughout the countryside is therefore increasing, and the malodours that are associated with this are also increasing.

There are approximately 130 million tons of farm slurry to be disposed of annually. Bearing this in mind, waste management has now become a matter of the least expensive method of disposing of a valuable resource.

Effective farm waste disposal or treatment is the result of good managment and farm husbandry. Farmers must be encouraged to return this resource back to the land (without causing offence or a nuisance), even if that encouragement should require financial support via Government grants.

Slurry Storage

Many farmers are limited to certain times of the year during which they may spread slurry due to one or all of the following factors:-

1. Weather conditions which render the land as "not go-able" and not wanting to spoil the land with excessive machine movement.

2. Not wanting to spread in autumn and winter, which if done, reduces the amount of nutrients in the slurry available to and required by the crops in spring and summer.

3. The lack of their own and/or contractor's labour to carry out the work schedule.

4. The insufficiency of land, associated with some intensive livestock units, for the adequate and nuisance-free, slurry-to-land disposal.

Most E.H.O. and planning authorities are conscious of effective storage as an essential element of good manure management. Any storage system under design should certainly be not less than four months; storage space for six months of waste would be ideal. A a general rule, one pig will produce one gallon of slurry per day. It will seem, therefore, that a 200 sow unit and their progeny (2000 pigs) will require tanks in the order of 1500 cubic metres (six months storage). Unfortunately, stored slurry is generally more offensive than fresh slurry, due to the anaerobic conditions created during storage. Rainwater should not be permitted to enter the slurry storage tanks.

HUMAN SLUDGE TO LAND

The use of human sludge as a fertiliser, but primarily as a soil conditioner, is being increasingly promoted by R.W.A.'s. In some circumstances, the local farmer is blamed for incidents of foul smells when in fact, the culprit is the R.W.A. spreading human sludge by their own or contracted labour workers.

Approximately 1.25 million dry tonnes of sludge are disposed of by Regional Water Authorities.

It is disposed of in the following ways:

Disposal	Percentage	
1. To Sea	23	
2. To Land		
(a) Grazing	16)	
(b) Arable	25)	
(c) Horticulture	2)	
(d) Forestry	1)	74%
(e) Reclamation	5)	
(f) Tipped	23)	
(g) Allotments	2)	
3. By Incineration	3	
	100%	

Many R.W.A.'s are now, for principally economic reasons, disposing of human sludge on to the land as a fertiliser and as a soil conditioner.

We believe it is appropriate to draw attention to some fundamental points relative to the strategies of R.W.A.s which involve the broad interest of district councils as public health authorities, in sewage sludge disposal provision for the community.

Whilst it is true that there have always been areas where some liquid sludge has been spread directly onto land, we submit that this activity was very modest in scale and, in any event, a very localised activity. This historical picture bears no comparison with the new situation which clearly envisages a continuing move to the position where most sewage sludge is spread directly to land in liquid form. This introduces an entirely new consideration from the public health point of view. It involves disposal in the rural areas of very large volumes of liquid sludge produced in the conurbations and, clearly, the scale and nature of the problem is entirely different.

As more and more sludge is spread onto land in liquid form, existing sludge treatment facilities ranging from digesters to presses and incinerators, which have been built up at great capital cost, will inevitably be run down. These facilities will be virtually irreplaceable because of the cost implications, both capital and operational. The eggs will then be very firmly in the one basket of disposal of liquid sludge to agricultural land. That land will remain in the ownership of private land owners and the disposal system will obviously depend on their goodwill and co-operation.

It is for Regional Water Authorities to satisfy themselves on these considerations.

The Regional Water Authorities, in accepting the undoubted and important economies of the system, should resist any temptation to subjugate safety and efficiency to cost reduction. This philosophy should also apply to any unacceptable practices protected by contractual commitments where these might be eliminated by financial means. These principles are important not just for the community in general but also for the continued acceptability of any system.

THE SPREADING OF ANIMAL SLURRY & HUMAN SLUDGE

MAFF have indicated that to gain the maximum fertiliser effect on any land, it is considered that not less than 6,000/12,000 gallons maximum per acre per annum should be applied. Where disposal is the only factor to be considered, then up to 20,000 gallons per annum per acre (maximum application rate 2,000 galls/acre at any one time) may be applied but this must be subject to the approval of the Regional Water Authority.

For many years some farmers have regarded the disposal of farm slurry as a necessary evil. Despite the economic pressures that have been applied to the industry over the past few years there are still some farmers who regard it in the same light. However, the cost of artificial fertilisers and other escalating costs has prompted and created an intensive study of slurry handling techniques under the aegis of the Agricultural Research Council and MAFF. Unfortunately, government cuts are curtailing this programme. Private enterprise is also showing a great deal of interest in this tremendous task.

Slurry handling is a complex function. There will be several acceptable working economical solutions to this particular problem. The intensification of pig husbandry units has highlighted the problems of secure handling by the British farmer.

The problem of odour nuisance is especially prevalent where field spreading of slurry and sludge is practised adjacent to residential or recreational areas.

The deterioration of amenities caused by slurry and sludge waste handling has brought about an acute need for effective methods of odour and sludge pollution control if the intensive livestock units and the spreading of effluents are to co-exist with their neighbours.

When spreading slurry and sludge, care should be taken not to spread close to habitable dwellings unless injection type methods are used.

It should be made clear that effluents must only be applied as a thin surface layer and that only minimal ponding of the effluent on the surface should be allowed.

The use of the rain gun for the application of animal and human effluents should be prohibited.

This crude and offensive system operates by pumping sludge under pressure through movable distribution pipes and spraying it high into the air. It is not only a severe nuisance risk but we consider that it also involves a serious microbiological hazard. Bacteriological sampling downwind of a rain gun used for pig slurry in the Scunthorpe area revealed:-

A rain gun in operation

(a) Calm conditions - bacterial count fell with distance but still some excess organisms three-quarters of a mile downwind.
(b) Windy conditions - heavy bacterial pollution still evident five miles downwind.

The spreading of effluents on grazing land should be avoided wherever possible. The technical information regarding the safe period allowable before grazing commences after spreading shows such differences of opinion that it would be unwise to adopt a period of less than six months until firmer evidence is available (See Report No. 20 N.W.C. - D. of E.).

Additional Comments

For the reasons set out in this Paper and because we believe use of the rain gun should be prohibited, any strategy should recognise in full the need for the provision of adequate sludge storage arrangements at sewage treatment works as part and parcel of the disposal system. Facilities for sludge digestion should not be run down. It is interesting to observe that in some areas, district councils have insisted, by conditions in planning comments, that intensive livestock units should have some four to six months slurry storage capacity and some water authorities have pressed for the same standards, as a planning committee.

It is essential that any water authority should ensure from the outset and as part of its strategy, that sufficient and specially trained staff are available to monitor and enforce the relevant codes, practices and safeguards. Whilst human error is extremely difficult to eliminate, particularly during a system development phase, it has to be accepted that sewage sludge has such unpleasant characteristics that any incident can cause quite severe nuisance, pollution risk or situations which are not acceptable on public health grounds. Any strategy must make control provisions accordingly.

Methods of Spreading

(a) Slurry Tankers

There are many models available on the market today varying in carrying capacity from 800 to 3,000 gallons. Experience has shown that the farmer uses the traditional splash plate tanker because of the following advantages:-

(i) Basic design is simple and consequently relatively easy to maintain.
(ii) Comparative low capital costs.
(iii) Will operate relatively fast as compared with other methods.

Its main disadvantage is that it invariably causes a public health nuisance.

(b) Direct Injection

The slurry is injected directly into the soil via hollow

Direct Injection of Pig Slurry

tynes placed behind the coulter cutting discs. Requires higher motive power to do this. Costly, but very effective for odour control. Cannot be used on all types of soil. Y.W.A. recent test trials, using an international 1055 tractor and the B.K.W. 1500 tanker and injection equipment, indicated that an application rota of 1000 galls/3.1 s/mins can be achieved (not including tanker filling time).

(c) Slurry Bar Trickle System

A simple unit that can be attached to the conventional slurry tanker which allows slurry to be guided to the soil via two sturdy PVC curtains. Cheap and effective of odour control.

(d) Modified Splash Plate Tanker System

This system which operates under less pump pressure modifies the slurry fan profile. The result is that the profile of slurry spray is practically parallel with ground level. An excellent compromise.

(e) Slurrymatic Type Machinery

Briefly, this type of machinery consists of a large pipe drum mounted on wheels and on either side of the equipment is a spreading boom (about 14 m in length and suspended some 750 mm above ground level). The pipe on the pipe drum is connected to either an irrigation system or a ground storage tank. The equipment is towed over the land at a slow speed by an independent power unit - very effective.

(f) Modified "Rain Guns"

To give low profile spread. The "rain gun" is a crude and offensive piece of equipment. Its use cannot be justified for the spreading of effluents and in our opinion statutory prohibition should be introduced.

NOISE NUISANCES

(a) Grain and Grass Drying

It is customary now for farmers to dry grain and grass before storage. This is a process which continues over a number of weeks and often is continuous for twenty four hours each day.

The machines used to produce the necessary warm air are noisy and give rise to noise nuisance to residents over a fairly wide area.

Advice from the Environmental Health Officer on screening the noise source etc. invariably brings about a rigid reduction in noise levels and an immediate appreciation from the complainant.

Farmers generally appreciate the help and advice offered and we are of the opinion that present legislation is adequate for the control of noise nuisance experienced in agricultural premises.

(b) Chicken and Other Rearing Sheds

The ventilation system in rearing sheds also provides another source of nuisance in the form of noise from the operation of the extractor fan. Problems arise principally because the fans operate night and day over long periods and the ambient noise levels in the vicinity are invariably of a very low order. Regular maintenance and the fitting of appropriate baffles etc. are required to alleviate the problem wherever necessary. Wherever possible new units should be placed 600/800 m from residential properties.

(c) Audible Bird Scarers

Many complaints of noise nuisance are received annually especially when these devices are sited close to residential property or left to operate all night, or if several devices are operating simultaneously in the same locality.

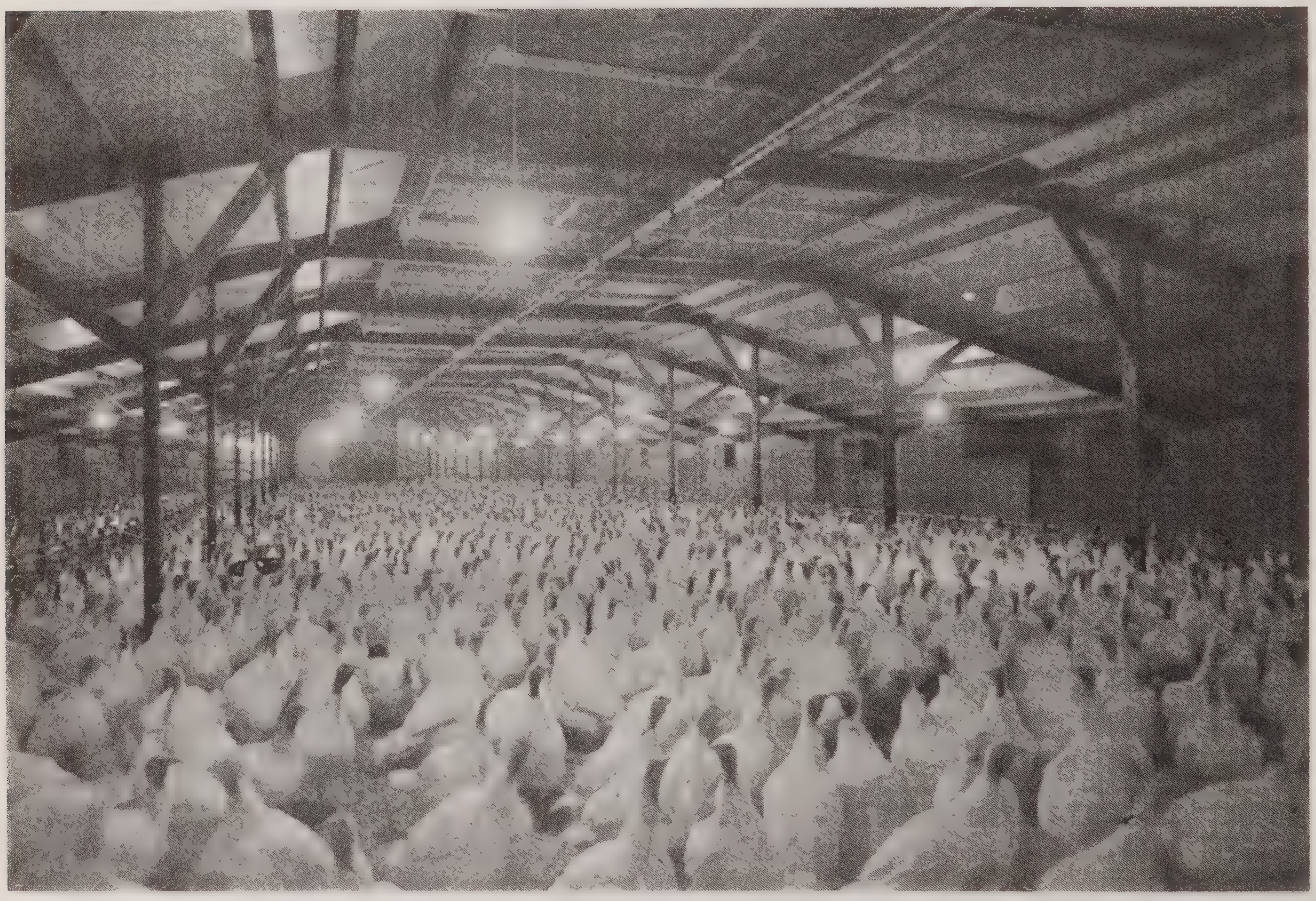
The Department of the Environment issued a consultative paper in 1976 on a proposed Code of Practice which claims that these devices, giving off loud bangs or reproducing the birds' distress call, are indispensable and no suitable alternative is available during the vulnerable crop growing season (2-6 weeks).

The Code includes restrictions on hours of use, intervals between activations, distance apart and distance from schools, hospitals and houses as well as maximum sound levels and the use of directional baffles. It is still of some concern that justifiable complaints continue to arise and some form of prior notification should be given to the local authority when problems could be forseen and dealt with informally. For example, the use of modern audible bird scarers which have a photo electric cell incorporated in the device means that the devices cease to operate just before dusk and begin to operate well after dawn has broken.

DUST AND SMELL EMISSIONS AND ASSOCIATED PROBLEMS

(a) Dust from Chicken Rearing Units

(i) Associated with smells extracted from the chicken rearing houses there is a certain amount of dust emission. This dust originates partly from the feeding stuffs and partly from the bedding. The dust can cause considerable nuisance in the neighbourhood of nearby



A Rearing Unit Containing 40,000 Turkeys.

dwellings, and consideration should always be given to the design of appropriate extractor fans and apparatus to allow for filtration of the emission to extract the bulk of the dust entrained in the emission. Such a precaution is particularly necessary if the rearing houses are sited close to residential and other dust sensitive properties. (See also note under Noise Nuisance - distance from properties).

(ii) Warren Spring Laboratory - Experiment Work with Biological System for Eliminating Agricultural Smells

The Soil Bed Technique

The system involves the collection of all extract gases through a manifold system to a collection point. The gases are then fed through an earth bed approximately one metre deep, where microbial action removes the smell. Practical problems arise with the amount of ducting required for collection, and the area of land needed for the soil beds, although no definite figures have been given on this later point.

The system has so far been used only for maggot farms and with reasonable success, but it is hoped that it will prove effective for other establishments particularly poultry houses. However, first reactions from the poultry trade express concern about the effect on the efficiency of existing ventilation systems when air flow during the last few weeks of growth is critical, and the cost of any related works of adaptation.

(b) Wind Erosion or Soil Blowing

Most types of sandy soil are very susceptible to wind erosion. The severity of any "wind blow" is affected by a number of factors but erosion generally begins with the movement of the relatively fine particles, which in turn leads to the creeping of coarser particles along the surface and the whipping up of dust particles and their suspension in the wind. Soil blowing is seldom recognised as a nuisance by members of the general public.

Even when dust storms are so severe as to cause motorists to drive with dipped headlights and soil to drift on roadways, complaints are seldom received.

The dust from agricultural land is likely to increase where linear farming is extended. The continued practice of removing hedges, fences etc. accentuates the dust problem. Likewise, the effects of blowing can be expensive to the farmer; loss of seed, fertiliser and herbicide, and crop damage from sand blasting frequently necessitates re-drilling and often results in reduced yields. Furthermore, field drainage can be disrupted.

Vinamul 3270 is a water based synthetic resin dispersent which on dilution and spraying binds the soil surface leaving no loose particles that may be moved by the wind. It is non-toxic and its resin content is gradually broken down in the soil. Approximately 6/8,000 acres of land in England and Wales are treated in this manner each year. The cost of treatment is around £40.00 to the acre and this method of abating dust nuisance has been used extensively in other industries over many years.

FERTILISERS AND PESTICIDES

There appears to be little nuisance from the application of fertilisers and pesticides except where applied by aircraft. The problem of disposal of pesticide containers has been raised by a number of organisations.

AERIAL SPRAYING

Despite National Farmers' Union and Civil Aviation Authority Codes of Practice, complaints are received annually during the crop spraying season and it is often found that the basic recommendations have been ignored.

Residents in the area, bee keepers and adjoining occupiers of agricultural business premises are often not informed that spraying is to take place and the required warning notices are not posted. Aerial spraying often takes places very early in the morning

(6.00 a.m. and before) and incidents have been reported of property, market garden produce and persons being contaminated by chemicals drifting from the area of application. We are not aware that there has ever been a national survey undertaken by the National Farmers' Union, Police, Civil Aviation Authority, Contractors, Health and Safety Executive and the local Health Authorities to ascertain whether there is a need for tighter and stricter control.

STRAW BURNING AND STUBBLE BURNING

The Royal Commission (7th Report 1979) accepts that stubble burning has been practised for many years and is considered to be good agricultural practice because of its beneficial effects in controlling crop disease and weeds. Straw burning is a more recent development and is the result of changes in livestock husbandry and in patterns of agriculture. The Commission were informed by MAFF that straw burning is to be seen as a method of disposal which is adopted because there is not better alternative.

The other disposal option that is directly available to farmers is that of ploughing in the straw, preferably after chopping, as is done in some other countries. This method is more expensive, however, and under some conditions, as especially in heavy soils, it can result in adverse effects on future crop yields becuase of the reactions within the soil.

Straw burning has now become widespread and the practice causes much public concern. The smoke and smuts from burning may cause substantial air pollution in the locality and may pose a hazard to traffic if the smoke blankets the roads. Unless appropriate precautions are observed the fire can damage trees, hedges and wildlife and endanger crops and buildings.

The Royal Commission has not thought it necessary to consider the problems arising from straw burning in detail because they have been fully examined by other bodies (notably by the Advisory Council for Agriculture and Horticulture in England and Wales, a report being published by them in 1973) and partly because it appears that the problems have decreased with the growing appreciation by farmers of the risks and the wider observations of the code of practice. The Commission also stated that it is perhaps worth knowing that in spite of the attention which has been given to the matter there appears to be little firm and comprehensive information about the damage caused by the practice. No information is collected by the Home Office that specifically relates to fire damage by straw burning and the Nature Conservancy Council have stated that the practice continues to cause damage to hedges, trees and woodlands, although the overall effects have never been assessed. The data for the cost benefit analysis are therefore not available.

It accepts that there are various possible other uses for straw but the general factor affecting the viability

Stubble Burning, North Yorkshire - 1982

of most of these is the cost of transporting the straw. They have been informed by the various agricultural departments that the alternative uses are not likely to take up the quantities of straw produced and that burning in the field will be required for the foreseeable future.

The Commission would also wish the development and exploitation of other uses for straw to be encouraged and so avoid the waste of this resource.

Nevertheless, the Commission accepts the need in the present circumstances for straw to be continued to be burnt in the field. The powers available to deal with the problems that may arise from straw burning appear to be adequate at present at least so far as risk to life and property and the causing of a nuisance are concerned. In addition to action through the nuisance provisions of the Public Health Act 1936 and section 140 of the Highways Act 1959, local authorities may make byelaws under the Local Government Act 1972. Many authorities have introduced byelaws based on a model prepared by the Home Office which incorporates the enforceable provisions of the N.F.U. code of practice.

Compared with other industries which are subject to strict controls on smoke and other emissions, agriculture is in a privileged position on the matter of straw burning. The privilege imposes special obligations on farmers, not least in their role as custodians of the environment; a disciplined and conscientious attitude is essential.

The major changes in the new N.F.U. Straw and Stubble Burning Code 1982 are:-

- No more than 12-16 hectares should be burned at a time. Larger fields should be burned in sections.
- The minimum firebreak width for stubble burning is increased to 15 metres cultivated or five metres ploughed adjoining any of the listed features.
- Burning should not be started when wind speed exceeds

Force 3 (8-12 mph) or when wind direction is likely to create a hazard from smoke or smuts.

- Where burning with the wind is unavoidable, width of the firebreak at the downwind end should be 45 or 55 metres depending on the adjoining hazard, i.e. a further 30 metres of straw clearance in addition to the standard firebreak.
- After more than two weeks of hot weather without rain, extra precautions should be taken to prevent the sort of damage and contamination by smuts that occurred in 1981.

However, the National Society for Clean Air do not feel that the unenforceable N.F.U. Code is sufficient and are suggesting that legislative backing and outside enforcement should be introduced. In this connection the Society and the writers of this paper see a parallel between the control of pollution from straw and stubble burning and the control of construction site noise. The Control of Pollution Act 1974 (Part III Section 60 & 61 refer) accepts the inevitability of noise from construction sites, but gives local authorities powers of prior approval permitting the enforcement of a Code of Practice. Similar powers in relation to a suitably modified N.F.U. Code could, for example, enable:-

- appropriate limitations to be placed on the extent and contiguity of proposed areas of burn with the object of reducing smoke concentrations upwind of urban communities.
- prohibition of burning during certain defined forecast weather conditions, e.g. during prolonged dry periods, or where wind velocity and/or temperature inversions appear conducive to the creation of a nuisance.
- prohibition of dark smoke from ignition agents such as old tyres.

Clearly controls of this nature would have to be applied in a reasonable fashion but, as with construction site noise, we consider that local authorities would have sufficient local knowledge which would enable them (consulting as necessary with adjacent authorities) to approve burning in the best interests of the community and the farming industry.

A LOOK INTO THE FUTURE

The Royal Commission's 7th Report (Agriculture & Pollution) made 81 Recommendations and drew conclusions which were submitted to H.M. Government concerning five major topics. Of the recommendations concerning farm wastes the following are especially worthy of your attention.

Recommendation 46

Intensive livestock units should be regarded as industrial enterprises.

Over the past 20 years rapid changes have taken place in the farming industry and the report supports the idea that some farms have changed into factories for converting grass or grain into meat and eggs.

Conclusion 47

Treatment systems which reduce odour problems have been adopted to only a negligible extent in the U.K. farming world - cost is an important and deciding factor.

The industry must come to accept the responsibility for the cost of pollution.

Recommendation 48

Grant aid systems should be reviewed (existing systems are often illogical). Pollution control should be regarded as an integral part of any development and should be grant earning.

Recommendation 49

Where I.L.U.'s are overtaken by urban development (not the fault of the farmer) and smell problems are created, compensation to the farmer should be made for the cost of treatment facilities (sec. 100 Public Health Act 1936 - no compensation).

Recommendation 51

The programme of research on waste management and smell abatement techniques should be reviewed.

Recommendation 52

Official testing arrangements should be introduced to provide independant assessments of waste treatment plants and techniques - a kind of Farming "WHICH".

Comment

There is a need to recognise that there may come a point in the continuing strive for higher agricultural yields where agricultural advice MUST give way to environmental considerations.

The writers completely support these recommendations and comments and urge the Department of the Environment and Ministry of Agriculture, Fisheries and Food to implement them as soon as practicable.

THE NEED FOR FURTHER CONTROL

(a) The Department of the Environment is considering the possibility of introducing new legislation as an important feature of odour pollution control which, as we understand it, would enable a local authority to serve an anticipatory notice on a potential offender. Should the nuisance occur it will automatically be deemed to be a statutory nuisance without formal notices and procedures. We support the idea of this proposed legislation and would urge that it be introduced as soon as possible. This provision would be in line with the present noise abatement legislation.

(b) Part III of the Control of Pollution Act 1974 should be brought into effect. This would afford control over the pollution of "relevant waters".

(c) By regulation the use of "rain guns" for the spreading of animal or human sludge should be urgently phased out.

(d) Until alternative methods are found a code similar to the N.F.U. code on straw and stubble burning should be reinforced by legislation. (Parallel with construction site noise).

EXISTING LEGISLATION

The statutory powers generally available to a local authority are in the main sufficient to deal with most situations but there are certain pollution problems that do not respond to the usual provisions of the law. A local authority can then take alternative action and it is suggested that some authorities may wish to examine Section 100 of the Public Health Act 1936.

It reads as follows:-

"If in the case of any statutory nuisance the local authority is of the opinion that summary proceedings would afford an inadequate remedy, they may in their own name take proceedings in the High Court for the purpose of securing the abatement or prohibition of that nuisance, and such proceedings shall be maintainable notwithstanding that the authority have suffered no damage from the nuisance".

A further piece of legislation which may also be used is the Local Government Act 1972. Section 222 gives wide powers to a local authority to take action for any type or kind of activity which is not statutorily defined as an offence or particularly defined in any other statute. Section 222 reads as follows:-

"(1) Where a local authority consider it expedient for the promotion or protection of the interests of the inhabitants of their area -

(a) they may prosecute or defend or appear in any legal proceedings and, in the case of civil proceedings, may institute them in their own name, and

(b) they may, in their own name, make representations in the interests of the inhabitants at any public inquiry held by or on behalf of any Minister or public body under any enactment.

(2) In this section "local authority" includes the "Common Council".

TO FINALISE

There is an old scientific saying - if one cannot measure it one cannot effectively control it.

With regard to any odour, this old saying cannot be more true today, as it was when originally stated many years ago.

In fact, no two people can accurately describe an odour to a third person except in very broad terms, such as nasty, sweet, foul, gassy, flower-like, which are quite meaningless, because it cannot be quantified or defined in accepted standard terms, understood by all concerned.

It is true to say we cannot be objective in our attitude to odours, we are always subjective.

We trust we have highlighted some of the agricultural problems that are presented to the Environmental Health Officer; considered their environmental impact and repercussions, and examined (from a Local Authority point of view) some possible solutions to what are sometimes euphemistically known as "fresh country smells".

ACKNOWLEDGEMENTS

1. M.A.F.F. General information Booklets Farm Waste Management 2077, 2200, 2081
2. M.A.F.F./A.D.A.S. The Storage of Farm Manures. 2273
3. Yorkshire Water Authority
4. N.F.U. (Straw & Stubble Burning Code 1982)
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nsca
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LLANDUDNO

THE CONTROL OF AIR POLLUTION IN THE MINERALS INDUSTRY

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1. INTRODUCTION

The removal of minerals from the ground and their subsequent processing has often been associated (except in favourably wet conditions) with the unwanted by-product of airborne dust. As with other industrial operations, this industry has in recent years achieved much progress in air pollution control and this paper indicates some of these areas of success and some of the problems still to be solved.

2. THE SCHEDULING OF MINERAL WORKS

Mineral Works was added to the Schedule of processes coming under Alkali Inspectorate control in 1971 and was defined as "Works in which metallurgical slags or pulverised fuel ash or minerals are subjected to any size reduction, grading or heating by processes giving rise to dust, including the subsequent handling of the products of any such process ......".

Although Alkali Inspectors had been asked to advise local authorities on the control of dust emissions for many years prior to 1971, the extent of the problem was set out in the Chief Inspector's Report for 1971 when he described the majority of mineral works as "dusty, unco-ordinated processes with bad housekeeping and inadequate arrestment or containment.".

The effect of scheduling was inter alia to place on the owners of these works the requirement to take the best practicable means firstly to prevent dust emissions and secondly to make residual emissions harmless and inoffensive.

3. THE ESTABLISHMENT OF BEST PRACTICABLE MEANS FOR MINERAL WORKS

In order to establish what "best practicable means" meant for this industry, meetings were held between representatives of their trade associations and the Alkali Inspectorate to study each section of the process in turn and to report on what was then current practice and the means to achieve improvement.

The British Quarrying and Slag Federation at the same time produced a booklet advising its members on the need to establish good public relations and communications, a subject which is referred to later.

The first published requirements came in 1974 with "Best Practicable Means for Roadstone Plants" covering all stages of the process from the primary crushing to the final coating operation. Standards of emission were stated based on the size of the operation and guidance given on the determination of chimney heights. Periods of grace agreed with the industry were included to obtain improvements to gas cleaning equipment which did not meet these standards.

Another important requirement under the Alkali Act is for new equipment to be given approval by an inspector prior to operation and it has become common practice for local inspectors and works managements to meet and discuss new proposals at the design stage. Plant manufacturers, who may be involved at this stage, found sometimes for the first time that they were being asked to give a written guarantee for the efficiency of a piece of gas cleaning equipment. The outcome, in the author's opinion, has been for a much better engineered product in many cases.

The range of gas cleaning equipment in use on roadstone coating plants can be seen in comparative figures for 1972 and 1981.

Year	No of coating plants	Fitted with				
		Electrical Precipitators	Bag Filters	Wet Washers	Cyclones	Nothing
1972	407	12	30	290	69	6
1981	343	0	75	265	2	1*

* Special "low-emission" plant

Bag filters or wet washers are now the standard equipment to be used for gas cleaning on these plants. Wet washers cover a variety of types with different efficiencies, from a venturi scrubber achieving a high efficiency of emission control, to a simple trough induced spray system having a more modest level of performance although operating satisfactorily when well maintained on some small coating plants.

It can be seen from the Appendix that "Best Practicable Means" is far more comprehensive than merely the installation of good gas cleaning equipment. Indeed Section 27 of the Alkali Act defines Best Practicable Means as having reference not only to the provision and efficient maintenance of such equipment, but also to the way in which it is used and to the proper supervision of the whole process.

The mineral industry, because of the gruelling conditions under which much of the equipment must operate, has a very large maintenance demand placed upon it. In addition to the abrasive effects on equipment of moving tens of thousands of tonnes of stone, many quarries are in elevated exposed positions struggling in the winter in near freezing conditions. The means to overcome these difficulties where air pollution control is involved (eg frost protection on dust suppression sprays) would be agreed at the prior approval stage.

Best Practicable Means covering the operation of plant includes the transport of raw materials and product to and from the processing plant which potentially can be a significant source of dust escape (see section 5). In addition, vehicle wheel washing facilities are required where necessary for vehicles leaving the works (Figure 1). These are installed not only to clean the dust from vehicles in dry conditions but also to minimise the coating of outside roads in winter with a layer of mud.

4. RELATIVE SOURCES OF DUST FROM QUARRYING OPERATIONS

Unless the stone is effectively dampened, any movement or processing will generate dust, as will the movement of vehicles on dry roads. If this dust is contained and extracted to cleaning plant before the final emission passes to atmosphere from a chimney, the mass or concentration of dust being emitted can be measured with reasonable accuracy to BS 3405 1971.

However, large quantities of dust can be generated from uncontained sources eg wind-whipping of stockpiles or quarry floors, vehicle movement and loading/off-loading operations. These are more difficult to quantify but an approximate assessment of their magnitude may be necessary to a manager who is attempting to reduce dust deposition rates outside his quarry, in order that any major expenditure would be likely to produce recognisable improvements.

At one large limestone quarry, a programme of investigation was carried out to obtain approximate values for uncontained emissions for evidence to a public enquiry.

For a projected annual output of 6 million tonnes, the following was obtained:-

a. Drilling - using efficient dust collectors, dust emissions should not exceed 0.1 tonne/day.

b. Primary Blasts - measurements taken at 400 yards downwind (ie ignoring the deposition of heavy particles inside the quarry) indicated a maximum escape of dust beyond that point of 0.1 tonne/day.

c. Wind-Whip from Quarry Floor and Vehicle Movement. Estimates of these dust sources during dry weather conditions and untreated roads would indicate an emission of about 9.1 tonne/day, which would be expected to drop to about 3.4 tonnes/day if the roads were treated with calcium chloride or another suppressant. The best estimate for wind-whip is about 1.7 tonnes/day leaving 7.4 or 1.7 tonnes/day from vehicle movement depending on road treatment.

These are considered maximum figures and from an examination of weather data to obtain the number of "dusty" days in the year, average dust emissions from these sources are:-

	tonnes/day
Wind-Whip	0.44
Vehicle Movement (untreated roads)	1.92
vehicle Movement (treated roads)	0.44

Thus an estimate of the average total uncontained emissions from these sources is about 2.6 tonnes/day (untreated roads) or 1.1 tonnes/day (treated roads).

Clearly these figures depend greatly on the weather conditions, and from experience maximum emissions are of greater importance than average values to people living in the area.

This quarry has a large number of processing plants (both registered and unregistered) and the total dust emissions from these plants is estimated at about 15 tonnes/day. It is likely that for quarries having fewer process plants, the ratio of uncontained emissions to contained emissions would be much greater.

5. THE CONTROL OF UNCONTAINED DUST EMISSIONS

DUST SUPPRESSION

It can be seen from paragraph 25 of the Notes on Best Practicable Means for Roadstone Plants (Appendix I) that where practicable, a policy of dust containment and arrestment is preferred by the Alkali Inspectorate. It has also been recognised that significant improvements can be achieved particularly on existing plant, with dust suppression techniques (Figure 2) using properly positioned fine water sprays often with the addition of a wetting agent to achieve effective wetting of the stone and dust. The amount of moisture addition for dust control varies depending on the material being treated and its inherent moisture content, but is usually considered to be less than 1% by weight for quarried stone. One gallon per tonne or about 0.5% is an amount often used for dust suppression.

Each system has to be properly designed for the individual application and allowance should be made of the possible need for additional sprays at a later date. The actuation of the sprays should be automatic and not left to an operator's memory. Where possible, sprays should be positioned to condition the stone before it is crushed, transferred or dropped from a belt. It is much easier to prevent the dispersal of dust from material being handled, than it is to suppress it once airborne.

Provision should also be made for the system to be adequately frost protected to allow continuous operation or continuous availability where appropriate. Effective pipe lagging and trace heating together with suitable protection of the wetting agent dosing system may be necessary.

Finally, experience has shown that although this provides a much cheaper alternative to that of containment and arrestment, a high standard of maintenance is essential often requiring daily checks of the sprays and corrective action for any that are damaged or blocked.

DUST FROM VEHICLE MOVEMENT

This is minimised where the movement of vehicles takes place on hard-surfaced roads that have been regularly swept. Clearly this is not practicable on many internal roadways whose locations may change periodically with a change in the area of quarrying. Section 4 indicated the high potential for dust emission from this source which particularly in prolonged dry periods may prove troublesome both to those inside and outside a quarry.

Water sprays from a bowser provide a short-lived solution, and some success has also been achieved using calcium chloride on unmade roads. This can either be applied as flake or as liquor. In the former, rapid deliquescence follows and the roads can be used within about half an hour. The use of this material keeps the roads in a damp condition even during prolonged drought (Figure 3). Recommended application rates are 1 kg/m^2 of road but the effectiveness is lost following heavy rain and the costs involved in using calcium chloride would need to take account of this.

It is also well-known that the seemingly modest provision of directing vehicle exhausts away from the road surface can considerably reduce dust emissions caused by vehicles (Figure 4).

SCREENING OPERATIONS

For new plant, best practicable means for screenhouses is containment of the dust and extraction to gas cleaning plant, or an alternative acceptable to an inspector. The volume of extraction required can be greatly reduced if the screens are enclosed as for example in Figure 5. The choice of system will depend on the particular circumstances and the condition of the stone being screened.

Improvements to existing plant have required a critical appraisal because of the potentially large expenditures involved. Some quarry managers have decided to seal up the screenhouse in order to prevent dust escape, with the internal dust generated falling through expanded metal flooring to the hoppers below. Clearly, this alternative would not allow an unprotected operative to work inside during screening and consideration of this would be necessary in conjunction with H.M. Mines & Quarries Inspectorate before any final decisions were taken.

This area of operation has proved to be one of the more difficult to resolve when looking for environmental improvements.

6. FUTURE WORK ON UNCONTAINED EMISSIONS

A Dust and Materials Handling Project has been set up by Warren Spring Laboratory as part of the Laboratory's service to industry. Membership of the project includes UK companies, government departments and like oranisations including H.M. Alkali Inspectorate together with certain non-UK companies.

The project will involve information surveys, equipment evaluation together with both laboratory and field studies with the overall objective of reducing dust emissions from materials handling systems. Present studies include container filling and emptying, conveyor transfers, powder processing and stockpile operations.

The Alkali Inspectorate as members of the project will be following developments with particular interest because although relevant to achieving further progress at mineral works, there are clearly potential benefits to be gained with other types of operation.

7. THE QUARRYING INDUSTRY IN THE BUXTON AREA

The Derbyshire hills around Buxton form a deposit of some of the finest limestone in the British Isles, with some outcropping of Basalt. This area in consequence has two seemingly incompatible demands placed upon it, that of a major industry undertaking processing to produce key raw materials for a variety of markets, and that of an area of great natural beauty drawing large numbers of people for recreational activities. It is here that the pollution control policies described earlier have been put to the sternest tests to achieve a situation which is equatable to these different local interests.

The limestone in Buxton has been quarried for several hundred years and from the time of the Industrial Revolution it has formed the raw material for an extensive lime burning industry. Disused quarries from past operations are common and have gradually weathered and blended into the area.

At the present time 10 quarries operated by 5 companies are carrying out scheduled processes (Figure 6). At three works, lime is produced, although only one is registered because gas-fired kilns are used at the remainder. A recent consultation paper on changes to the Schedule of processes coming under Alkali Inspectorate responsibility has proposed adding gas-fired lime kilns to the Schedule.

Dust deposit gauges surround the quarries, some owned and serviced by the local authority and the remainder by the quarry companies. All of the results are collated annually and presented to the Buxton Area Liaison Committee.

This committee was set up in 1974, not as a decision-taking body, but as a discussion forum with the objective of improving the means of communication between the companies, the local authorities and the general public. In this respect, it has proved very successful and has enabled for example both public complaints and industrial problems to be aired and understood by those present.

Average dust levels (soluble and insoluble) during the period are shown in Figure 7. A comparison gauge in a rural setting has shown a background deposit rate of about 100 $mg/m^2/day$. The soluble and insoluble components of the total dust results are determined by conventional techniques, and have been found to be present in approximately equal amounts in the average results.

Comparison of these deposit rates with others elsewhere in UK should only be carried out with great caution, since many of the gauges have deliberately been sited in areas of maximum deposition.

One large quarry which has had deposit gauges in the area for twelve years has seen average dust deposition levels halved in this period while "high level" emissions from process plant have been reduced by about 80%.

8. OTHER TYPES OF MINERAL OPERATIONS

Much of this paper has been concerned with operations within quarries because their operations through to the final products (coated or otherwise) represent the majority of works coming within the definition.

Nevertheless there are other important categories where major improvements have been achieved.

In 1981 there were 70 sand dryers in operation in England and Wales. Many are the conventional rotary dryers and associated coolers although some works have replaced these with fluidised bed dryer/coolers. High efficiency cyclones have achieved emission levels well within the current presumptive limits of 0.23 g/m^3 and the severe wear inside these cyclones because of the abrasive characteristics of the sand has been much reduced using a rubber lining. This can regularly be checked and repaired where necessary without the need to replace the section of cyclone. Other examples of mineral works are perlite/vermiculite works, plaster works and sintered aggregate works, all of which have individual requirements appropriate to their type of operation included in "Notes on Best Practicable Means".

9. SUMMARY

The scheduling of mineral works and the response by industry for a co-operative approach to solving its problems have produced a much improved overall picture for air pollution control. The step-by-step policy of "best practicable means" has enabled priorities for improvement to be identified and necessary action taken within agreed time periods. Despite financial restrictions which have been severe in many cases, outdated inefficient plant has been replaced to meet modern standards and improved procedures and controls have been implemented.

This should not be taken to imply complacency for the future. Much has still to be done in order to reduce emissions and the level of justified complaints of people living nearby. In 1981 nearly 10% of mineral works were the subject of complaint (or over 9 out of 10 were not, depending on one's point of view) which, perhaps as a consequence of the economic situation, was the lowest percentage since 1971.

During the same period, improved communication has developed between works managements and the general public in their areas both in response to complaints and at local liaison meetings, and has enabled both groups to have a better understanding of the difficulties and aspirations of the other.

ACKNOWLEDGEMENTS

The author would like to thank the Buxton and District Local Joint Liaison Committee for its agreement to publish figures from its unpublished minutes, ICI (Mond) Ltd for agreement to publish results of their measurements on uncontained emissions, and colleagues within the Alkali Inspectorate and members of Industry for advice on various sections of the paper.

Opinions expressed are those of the author and do not necessarily represent those of the Alkali Inspectorate or the Health and Safety Executive.

APPENDIX 1

B P M

Notes on
BEST PRACTICABLE MEANS

MINERAL WORKS

(ROADSTONE PLANTS)

March 1982

Health and Safety Executive: HM Alkali & Clean Air Inspectorate

In England and Wales the administration of control of air pollution for certain industrial processes is carried out by HM Alkali and Clean Air Inspectorate. The legislation which applies consists of the Alkali etc Works Regulation Act 1906 and Alkali etc Works Orders 1966 and 1971, and the Health and Safety at Work etc Act 1974. In Scotland similar administration is carried out by HM Industrial Pollution Inspectorate under an agency agreement with the Health and Safety Commission.

For several years 'Notes on Best Practicable Means' for various classes of the above works were published as appendices to the annual reports of the Chief Inspectors for England and Wales and Scotland. Since copies of these become unavailable after a time, and in order to make the Notes more easily obtainable, it has been decided to publish these Notes separately and as a distinct series.

INTRODUCTION

1. Mineral Works are defined as "works in which metallurgical slags or pulverised fuel ash, or minerals are subjected to any size reduction, grading or heating by processes giving rise to dust, including the subsequent handling of the products of any such process but not including works for the processing of coal, lime works, ceramic works or foundries except insofar as the process carried on is described in any other scheduled work". The crushing, screening, drying and coating of stone and slag for use as roadstone, etc. falls within this

definition and these Notes[1] apply to such processes.

2. The Act requires that the owner of registrable works[2] shall use the best practicable means for preventing the escape of noxious or offensive gases (which include smoke, grit and dust) by the exit flue of any apparatus used in any process carried on in the work, and for preventing the discharge, whether directly or indirectly, of such gases into the atmosphere, and for rendering such gases where discharged harmless and inoffensive.

3. The expression "best practicable means", where used with respect to the prevention of the escape of noxious or offensive gases, has reference not only to the provision and the efficient maintenance of appliances adequate for preventing such escape, but also to the manner in which such appliances are used and to the proper supervision, by the owner, of any operation in which such gases are evolved.

4. Attention is drawn to the need for prior approval by the Chief Inspector of appliances necessary to ensure that the works can satisfy the requirements of best practicable means.

5. Emission limits have been framed with practicability in mind, having regard to the difficulties of sampling and analysing emissions and of measuring flow rates in ducts and chimneys under industrial conditions. Reference to particulate emissions include smoke, grit, dust and fume.

6. All gas volumes are expressed as being measured at a temperature of 15^{0}C and pressure of 1 bar, without correction for water vapour content.

7. The provisions of these Notes relating to contained emissions shall apply to all relevant plant on roadstone works, to new process units, replacements, enlargements or any significant modifications to equipment on existing works and to plant[3] that is moved from place to place, whether between sites or at one site.

8. In exceptional cases and in the absence of justified complaint or of improved knowledge of the effects of emissions, plants may continue to operate to the limits and other requirements agreed with the Inspectorate. When they have operated for their economic lives the position shall be reviewed.

9. As regards adventitious, uncontained emissions, the requirements of these Notes shall apply to all fixed and mobile plants on roadstone works.

10. The Notes are intended to provide a basis for consultation between works management and the Inspectorate, with sufficient flexibility to meet the needs of special local circumstances. When using them, inspectors and works managements should also consider all relevant aspects of the Health and Safety at Work etc. Act 1974 which might apply. At the design stage, discussions should be initiated with the appropriate Inspectorates in order to co-ordinate all required features, thus avoiding the possible need for later modifications.

SAMPLING, MEASUREMENT OF EMISSIONS AND MONITORING

11. As part of proper supervision, the owner shall make tests and inspections of the process to ensure that the equipment is capable of achieving the required limits. The frequency and time of sampling will depend upon local circumstances and practices, and shall be determined to the satisfaction of the inspector after discussion with the works management. Particular consideration shall be given to new or replacement arrestment plant. The results of all tests and inspections shall be recorded and made available by the owner for examination by inspectors. Adverse results shall be investigated immediately and in all cases shall be drawn to the attention of works management as soon as possible so that corrective action can be taken.

12. Adequate facilities for sampling shall be provided on chimneys or ducts as agreed between works management and the inspector.

13. The reference test method for particulate emissions is that of BS 3405: 1971. The Inspectorate uses the apparatus developed by the British Coal Utilisation Research Association[4], mentioned in Appendix A of the British Standard.

14. An alternative method of testing to that specified in paragraph 13 is acceptable by agreement, provided that it can be shown that results comparable with this method are obtained.

15. It shall be the aim to install continuous monitoring instruments when suitable practicable units are available.

EMISSION LIMITS AND CONTROLS

16. The concentration of particulates in emissions to air shall not exceed 0.46 g/m^3 for aggregated site volumes of emission up to 700 m^3/min, reducing progressively to 0.23 g/m^3 for aggregated site volumes of emission of 1,400 m^3/min and above. The aggregated site volume referred to in this paragraph is that of contained emissions originating in coating plants, dryers and related equipment.

17. When new plant is installed at an existing works, its arrestment equipment shall be designed to meet the above limits on the basis of the new aggregated site emission volume. Existing plant at such works shall meet the emission limits relevant to the new aggregated site emission volume within time scales agreed between the inspector and works management, having regard to all the circumstances.

18. The concentration of particulates in any other contained emissions on site (other than from mobile or transportable plant), irrespective of their size, shall not exceed that concentration in force under paragraph 16.

19. The concentration of particulates in contained

emissions to air from any mobile or transportable plant on site shall not exceed 0.23 g/m^3. Within time scales agreed by the inspector, concentrations of particulates in emissions from fixed plant on such sites shall be reduced to the level necessary under the sliding scale arrangements of paragraph 16, taking into account the mobile or transportable plant emission volume in the revised site aggregate volume.

20. Emissions shall be maintained free from visible smoke during normal operations, and substantially free from persistent mist (excluding steam) or fume.

21. The emission from any chimney or final outlet shall be free from droplets.

22. Uncontained emissions eg. from stockpiles, conveyors or unenclosed crushers shall be substantially free from visible emissions of dust.

OPERATIONAL CONTROLS

Arrestment Plant

23. High efficiency scrubbing or bag filters are appropriate methods of arrestment capable of meeting the emission limits of paragraphs 16 and 18.

24. Other methods of arrestment are acceptable by agreement between works management and the inspector, provided that the emission requirements of paragraphs 16–22 are met.

Materials processing, handling and storage

25. In general and where practicable a policy of dust containment and arrestment is preferred by the Inspectorate. However, it is recognised that in some cases suppression techniques, where properly designed, used and maintained, can be an effective alternative means of control and may be the preferred method for certain operations. Where dust suppression at any stage in the process is agreed between works management and

inspectors, it is important that its overall effect on the process shall be taken into consideration in order to avoid creating process problems and dust emission at later stages.

Crushers

26. Crushing plant shall be fitted, where necessary in the opinion of the inspector, with an efficient means for the control of dust emission. Crushers should be designed to minimise the flow of air through the crusher and also to minimise the free fall of stone, particularly on discharge. Where suppression methods are used, good design, maintenance and operation are essential and frost protection should be incorporated. In dry weather, "conditioning" of stone fed to the primary crusher may be required. If the standard of control achieved is not to the satisfaction of the inspector, extraction and arrestment shall be used, to meet the requirements of paragraph 18.

Screenhouses

27. Dried stone shall normally be screened in enclosed equipment ducted to an arrestment plant, to meet the emission limit of paragraph 18. Any alternative shall be to the satisfaction of the inspector.

28. For undried stone screening, containment and arrestment, where necessary, is the preferred method of control. Any alternative means shall be to the satisfaction of the inspector.

29. Screenhouses should be reasonably dust tight with self-closing doors and close-fitting entries and exits.

30. Fine materials collected from arrestment plant should not normally be recycled to the screening operation.

31. Coating plant should be so designed and operated that there is no substantial emission of dust during the discharge of surplus dried stone or filler.

Conveyors

32. All exposed belt-type conveyors carrying materials susceptible to wind whipping shall be fitted with wind boards or their equivalent. Where such materials are conveyed, the belt shall be enclosed to such an extent as to prevent the generation of airborne dust.

33. Transfer points should be enclosed and fitted with flexible seals on inlet and exit and equipped to meet the requirements of paragraph 22. Where dried materials are handled, transfer points should be ducted to an arrestment plant to meet the limit of paragraph 18.

34. Conveyors shall be fitted with an effective means of cleaning which does not cause a secondary dust problem.

Surge piles and storage

35. Open surge piles following primary crushing should be kept to a practicable minimum. Conveyors should be adjusted to minimise free fall at all times. A chute should be used to protect falling stone from wind-whipping; suppression methods should also be used, preferably on the stone before it is put onto the conveyor. The same considerations apply to open stockpiles of scalpings.

36. Intermediate storage following secondary and subsequent crushing shall be sited and treated so as to minimise the generation of airborne dust. Emergency stockpiles of such materials should be sited in sheltered positions; the material shall be treated by dust suppression methods prior to stockpiling and the stockpile itself shall also be treated.

37. Loading to and from stockpiles should be carried out so as to minimise airborne dust. In dry weather, the stockpile shall be adequately wetted before being disturbed.

38. Storage silos for fine materials shall be enclosed

and vented to air through arrestment plant to meet the limits of paragraph 18.

Transport/Loading

39. Tankers carrying dusty non-waste materials shall discharge only into vessels fitted with an effective dust collecting system.

40. Internal road transport of dusty materials should be carried out in closed tankers or sheeted vehicles.

41. Loading of road or rail vehicles or ships should be carried out so as to minimise the generation of airborne dust, to the satisfaction of the inspector.

42. Surplus dust collected in arrestment plant or from other sources should, if dry, be transported in closed tankers; if prepared as a paste with water, open lorries may be used. Disposal methods to minimise airborne dust shall be agreed between works management and the inspector.

CHIMNEYS

43. Chimney heights for roadstone works shall be determined after discussion between works management and the inspector who normally uses for his first assessment the maximum rate of emission of flue gases and any significant pollutants. Particular consideration may need to be given to respirable quartz, odorous substances and the possibility of vegetation damage.

44. The chimney height so obtained may need to be increased to allow for local circumstances such as topography, nearby buildings and existing emissions.

45. The minimum chimney height shall be 3m higher than any nearby building or structure.

46. Chimneys or vents shall normally be designed for an efflux velocity of not less than 15m/sec at full load

operation. Where a wet method of arrestment is used, the linear velocity within the main barrel of the chimney shall not exceed 9m/sec to avoid entrainment of liquid from the chimney surface in the gas stream.

47. In order to obtain maximum advantage from thermal buoyancy, it is recommended that hot emissions take place from the practicable minimum number of chimneys. Unless there are sound technical reasons, a multiplicity of discharge points should be avoided. This is particularly important when new plants are being designed or when changes are being made to existing plant.

GENERAL OPERATIONS

48. Best practicable means applies not only to the control of emissions, but also to efficient maintenance, proper use of equipment, and adequate supervision of the process. Effective and efficient maintenance should be employed, an adequate supply of essential spares should be held and duplicate equipment should be installed whenever practicable and necessary to allow continuity of operations whilst minimising emissions to air.

49. Malfunctioning or breakdowns leading to abnormal emissions shall be dealt with promptly; in serious cases the process shall be shut down as soon as practicable for repairs. Whenever abnormal emissions occur which might affect the environment significantly, the local authority and the inspector shall be informed without delay.

50. Staff at all levels shall receive proper training and instructions in their duties relating to control of the process and emissions to air. Particular emphasis shall be given to training for start-up, shutdown and abnormal conditions.

51. A high standard of housekeeping shall be maintained. Roadways in normal use should be hard surfaced and kept clean to avoid dissemination of dust. The area of hard surfacing required shall be as agreed between the inspector and the works management. Vehicle exhausts

should not, wherever practicable, be directed below the horizontal. Wheel cleaning facilities shall, where necessary, be installed for vehicles leaving the works.

REFERENCES

1. These Notes supersede those published at Appendix VII of the 110th Annual Report on Alkali &c Works 1973.

2. An introductory note on the legislation relating to administration of control of industrial air pollution by HM Alkali and Clean Air Inspectorate, and giving details of processes registrable under the Alkali etc Works Regulation Act 1906 and the Alkali etc Works Orders 1966 and 1971, and of "noxious or offensive" gases, has been published as BPM 1/79, the first in this series of Notes.

3. If any part of a mineral works operation is sub-contracted, the owner of the main process/material will be assumed to have the obligation to meet the statutory requirements, unless there is a formal agreement to the contrary.

4. Full details of this method are given in "Measurement of Solids in Flue Gases", obtainable from the Institute of Energy, 18 Devonshire Street, Portland Place, London W1N 2AV

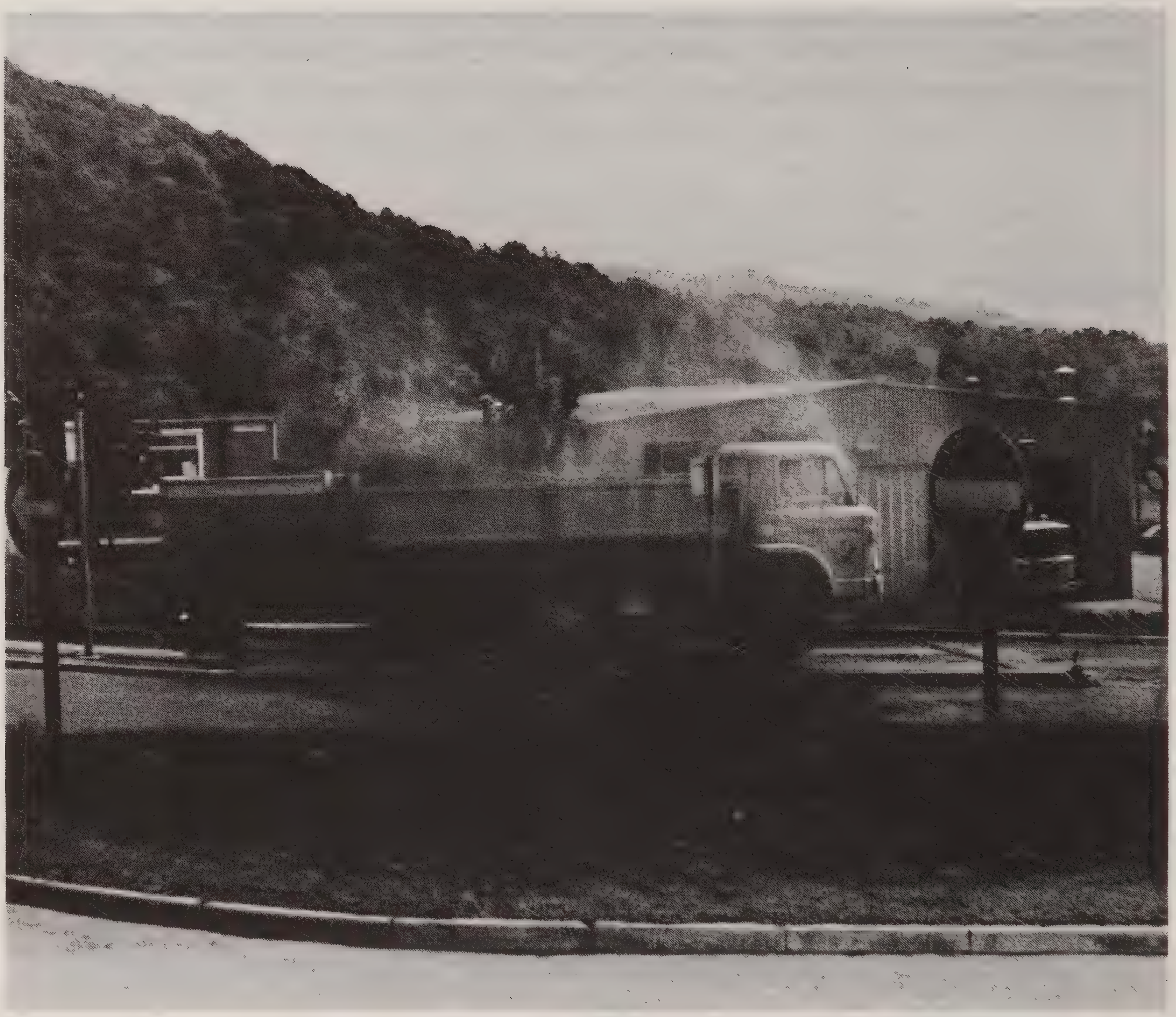

Fig. 1 - Vehicle Wheel Washer in use at Quarry Exit

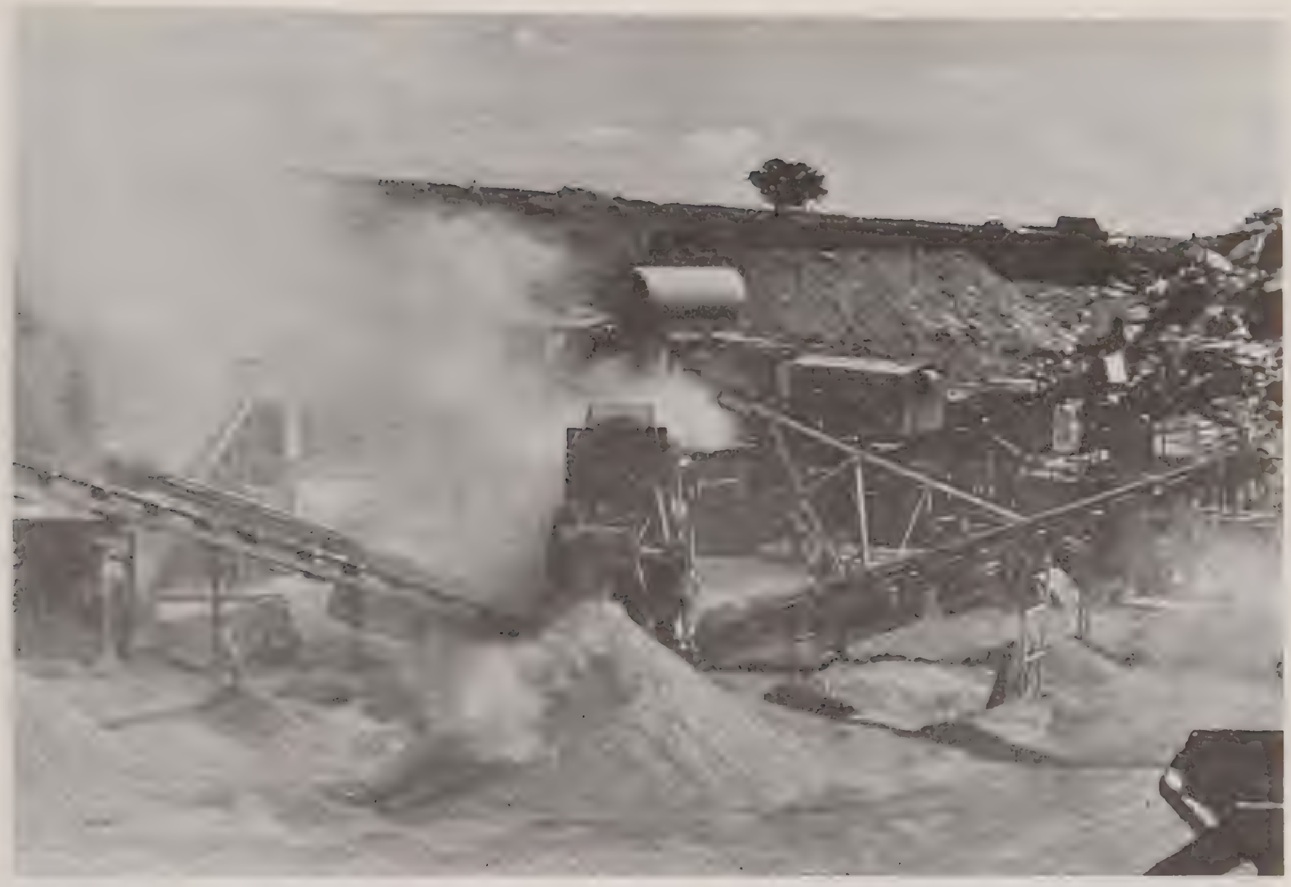

Fig. 2a - Typical Quarry Scene with Dust Suppression Off

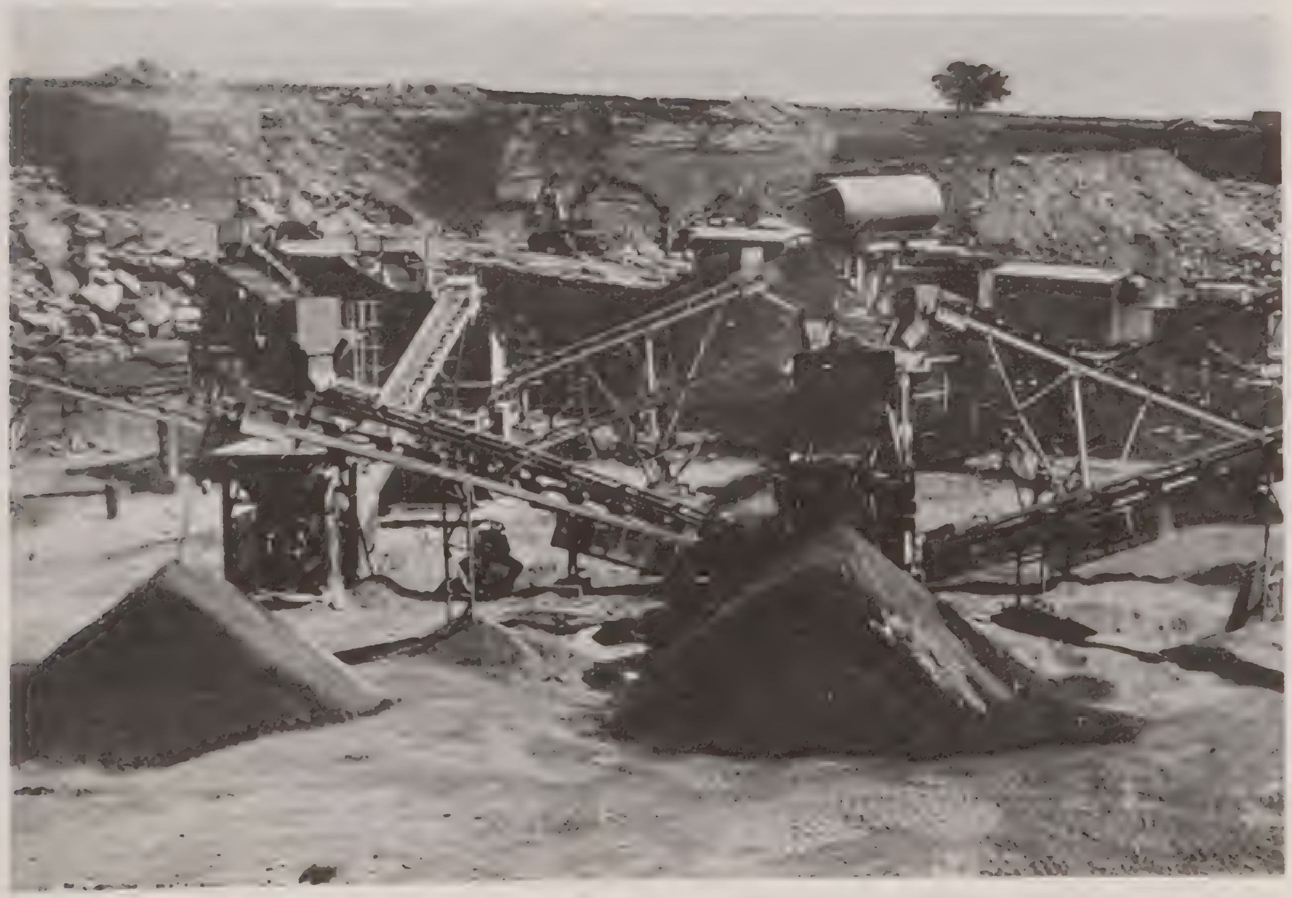

Fig. 2b - Typical Quarry Scene with Dust Suppression On

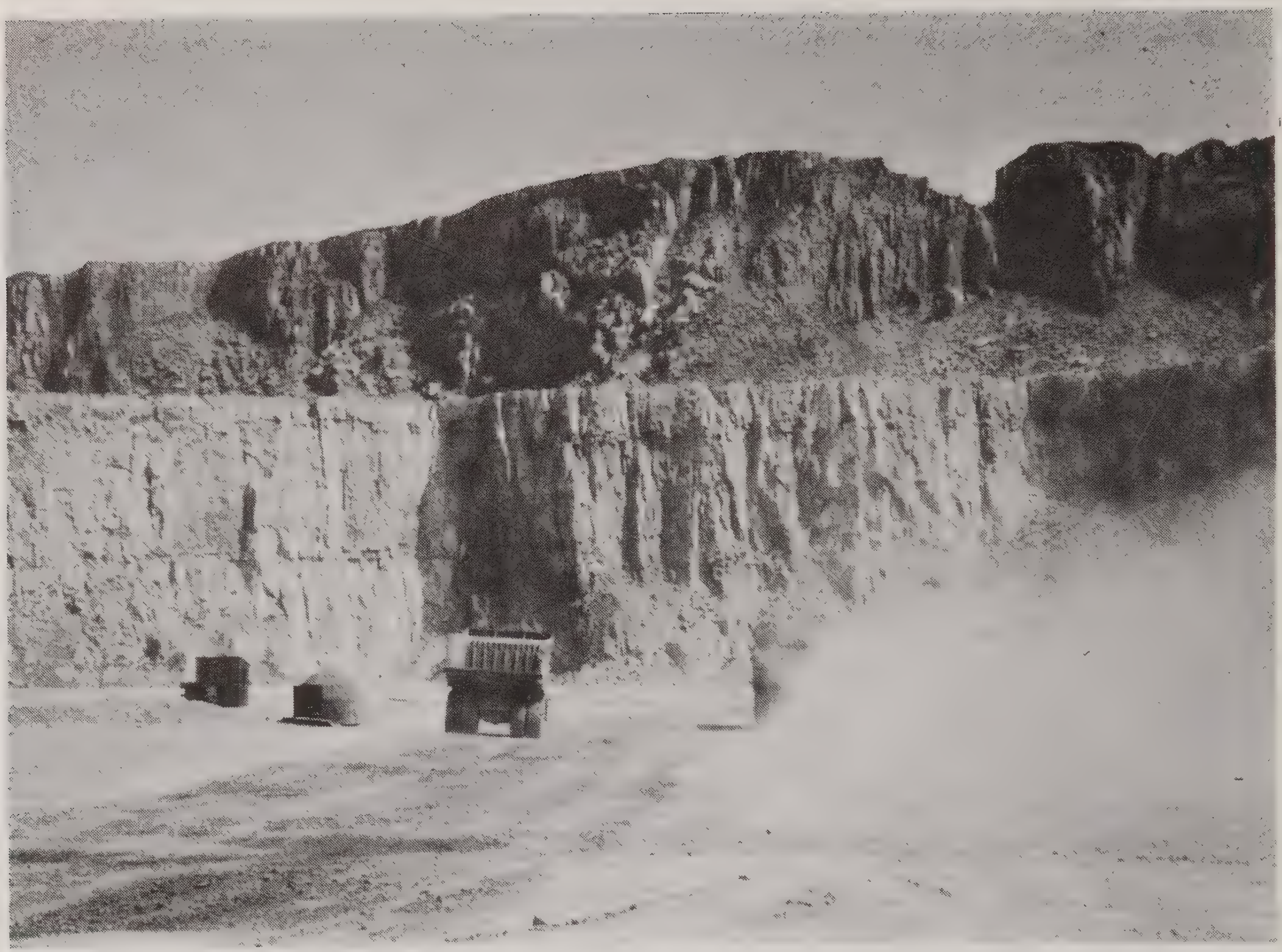

Fig. 3 - The Effect of Calcium Chloride in reducing dust from quarry roads. Both lorries are travelling at the same speed.

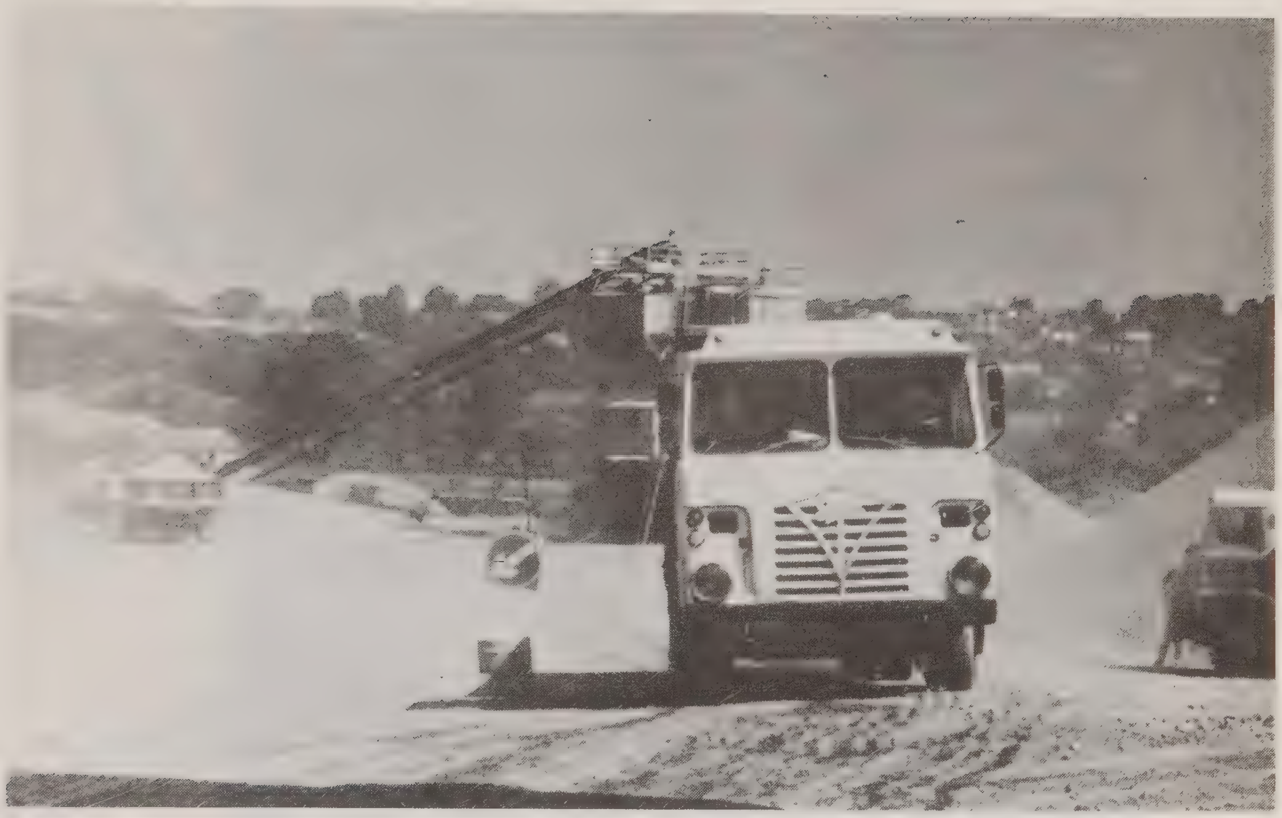

Fig. 4a - Lorries travelling at 10 mph - horizontal exhaust.

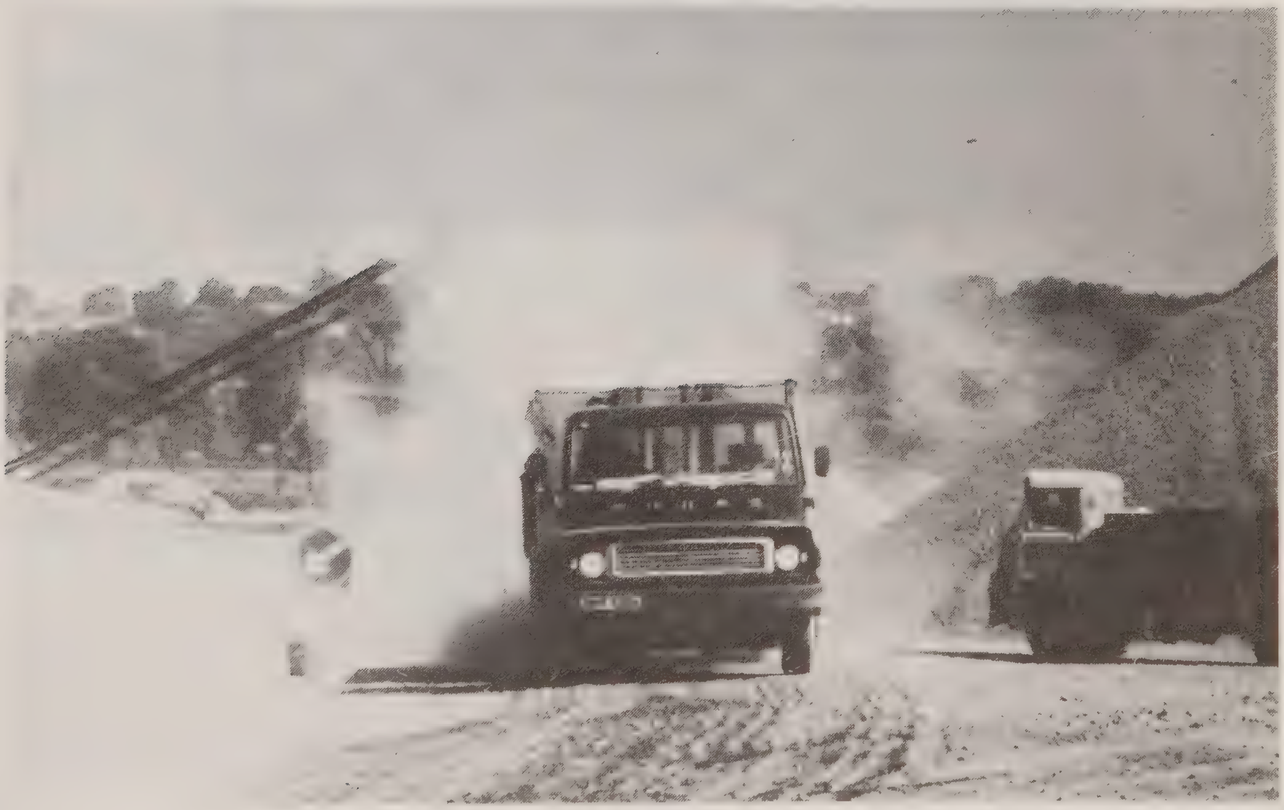

Fig. 4b - Lorries travelling at 10 mph - exhaust pointing downwards at an angle of 45°.

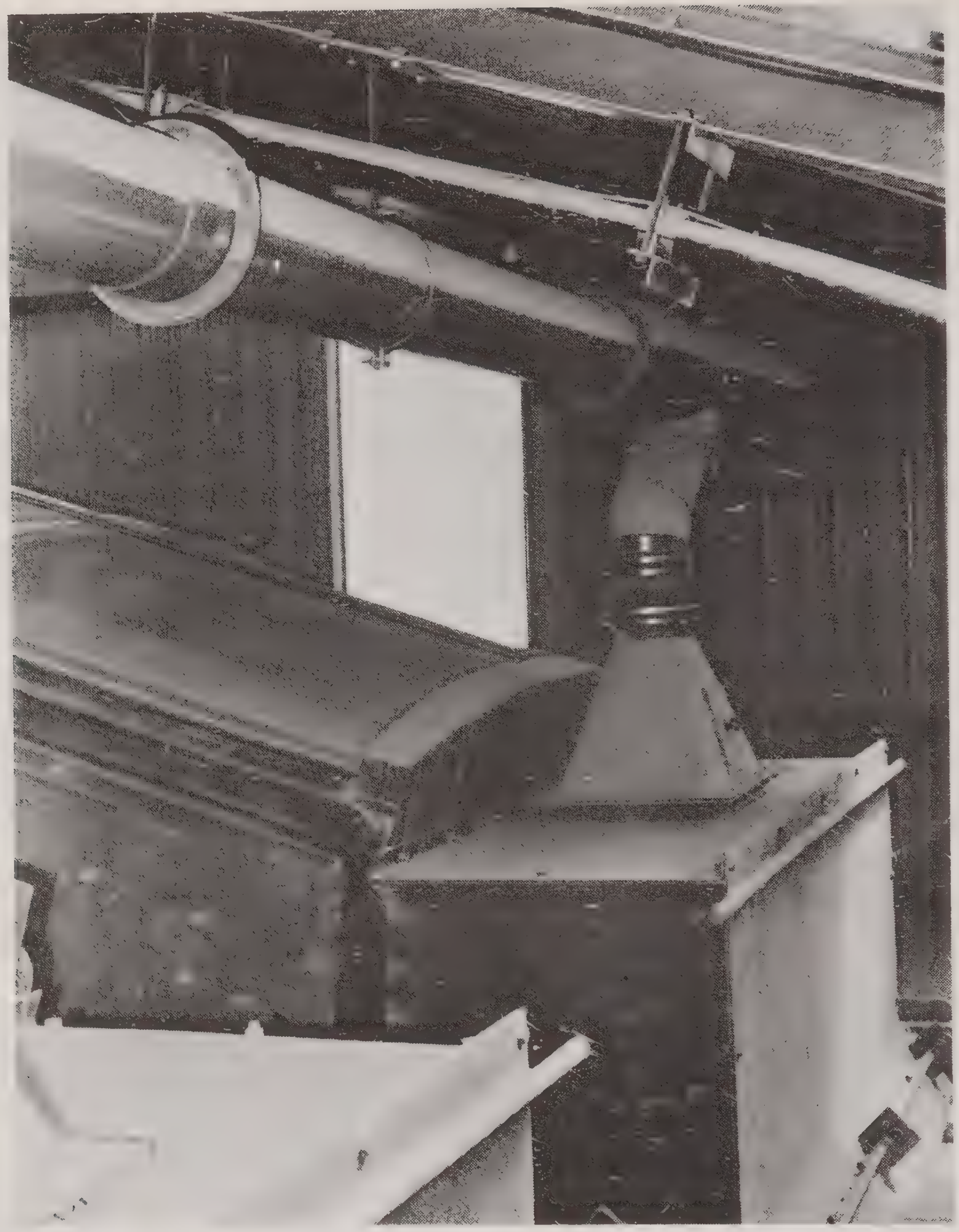

Fig. 5 - Enclosed screens with dust extraction at the discharge end.

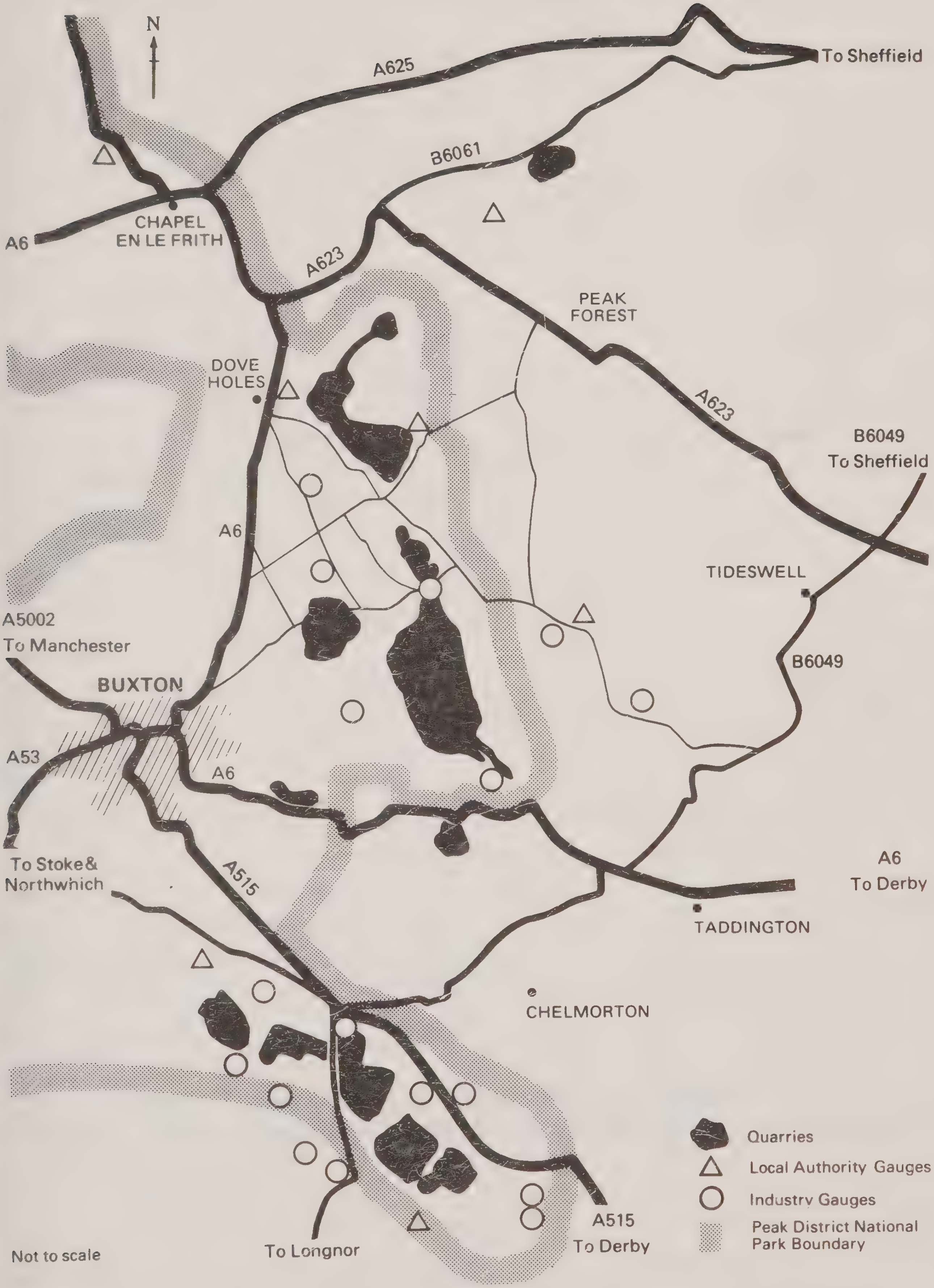

Fig.6 - The Quarrying Industry in Buxton

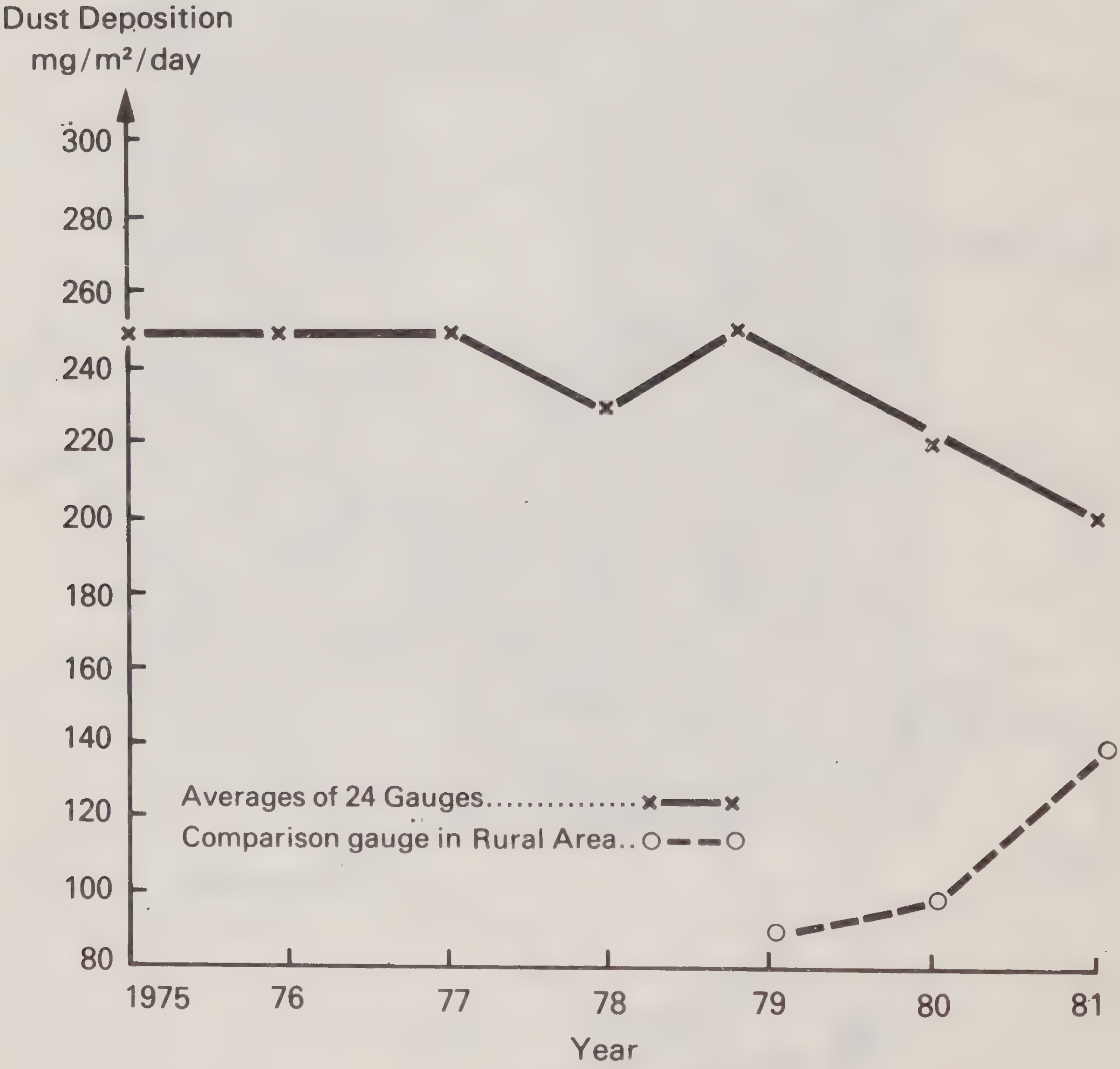

Fig.7 - Buxton and District Local Joint Liaison Committee
Graph shows annual trends of average dust deposit gauge readings

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– FURTHER PERSPECTIVES ON ACID RAIN –
IS THERE PROPORTIONALITY BETWEEN EMISSIONS AND DEPOSITIONS?
A KEY QUESTION IN THE ACID RAIN DEBATE

– By –

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INTRODUCTION

Everyone is aware that Europe has an "acid rain" problem. The media now and then turn our attention to the forests of Germany, Austria, Czechoslovakia and elsewhere which show varying degrees of pollution damage. They remind us of the fishless lakes of southern Norway and Sweden, of the build-up of heavy metals in some artesian waters, and of other worrying problems.

It would be wrong to suggest that these are anything other than serious problems but the question arises as to how best to set about solving them. It is easy to say, "Cut emissions", but of what species, and by how much, and what will the inevitable side-effects be?

Looking more deeply into the problem, it soon becomes clear that there isn't just one problem but several rather loosely connected problems. Forest damage in Czechoslovakia, for example, seems to result from the direct effect of sulphur dioxide, when in rather stable atmospheric conditions in winter, plumes are carried from power stations in the Polish-Czech border region into the wooded Tara Mountains. In Scandinavia the acidification of lakes and streams seems to be linked primarily to sulphuric and nitric acids obtained through oxidation of sulphur dioxide and nitrogen oxides emitted perhaps thousands of miles away and washed out in rain or snow. In Germany, on the other hand, the major factors seem to be ozone (produced by the action of strong sunlight on polluted atmospheres containing nitrogen oxides and hydrocarbons), climatic stress on the trees (very cold winters or long dry periods in summer), with perhaps wind-blown acidic fogs thrown in for good measure. To make matters even more complicated some of the effects take place quite quickly whilst others take a long time.

Cut emissions? Well yes, if we had no emissions at all that would in time solve the problem. But that is an impossible dream. A more modest reduction sounds more reasonable. But will it work? Air chemists tell us that there are circumstances which are not at all unrealistic, in which a reduction of nitrogen oxide emissions could actually result in an increase in ozone concentrations and potentially cause more damage to trees ...... and it may only require one or two bad ozone episodes to do irreparable harm to a tree given the right circumstances. Clearly then, we have to proceed with deep understanding and care even though the problem is desperately urgent in some areas. Sadly the base-rock store of good field data on which to build our understanding is often missing - the problem has come upon us too quickly to acquire the data we urgently need.

It is natural to turn for help in these circumstances to modellers who can try to simulate what they believe is going on in the real world, with certain simplifications and assumptions, and come up with numerical predictions of what should be happening. Of course the results are only as good as the physics, the assumptions, and the input data that have gone into the model; and I say that as a modeller myself! In practice, real field data of the highest quality and models, properly construed for the job, need to go hand-in-hand. Each needs the other.

Cut emissions? There is of course a big cost to pay. Initially the cost may seem to be solely financial; but often this will have repercussions in other areas: in employment, in social well-being, in other environmental areas and so on. Fitting bulky desulphurisation equipment to a modern power station would almost always entail a major rebuilding programme at enormous cost. Britain is building very few power stations in the 1980s although come the middle of the next decade many power stations built in the 1950s will be ending their expected lifetimes and will be up for replacement. Logically this would be the ideal time to include efficient desulphurisation units at a fraction of the cost of fitting to existing stations. But can we wait that long? Those suffering damage are inclined to say "No". Britain has however reduced its sulphur dioxide emissions from well over 6 million tonnes in 1970 to below 4 million tonnes now - an excellent achievement, even if some of this is due to the unwelcome and unplanned falling-off of our traditional heavy industries over the last few years. When our European neighbours call upon the UK to join the 30% Club (a "Club" of States dedicated to reducing emissions by the end of the decade to values that are 30% below their 1980 emissions) they must remember how much we had already achieved by 1980 compared to many of themselves.

All this should not make us complacent however. We are the third largest emitter of SO_2 in Europe, outside the USSR, and we should make it clear that we are as dedicated as any in trying to minimise environmental damage wherever it occurs, especially since we are upwind (in a climatological sense) of many of the sensitive areas of Europe.

Let us consider in a very broad-brush way where our emissions have their greatest impact. It is probably true to say that every source, wherever it is, must make some contribution to every ecological problem, no matter how small or large that contribution may be. But in broad terms I believe it can be argued that the German ozone problem is largely a regional-scale problem associated with stagnant summer anticyclones with light winds, the air "sloshing" around and becoming increasingly polluted in time. Since anticyclones are generally associated with low-level outflow for good dynamical reasons, the pollution eventually works its way outwards from the centre, rather than the reverse, and so UK emissions are unlikely to be deeply involved: they are pushed away from the anticyclone, not drawn into it. Similarly UK emissions must yield concentrations of SO_2 far too small by the time they reach Czechoslovakia to contribute in any measurable way to tree damage there.

Scandinavia is rather a different problem. I believe all the evidence points to a significant UK contribution. The wet depositions of sulphate over the Norwegian mountains are often associated with south-westerly winds and mobile depressions. Models and daily measurements point to a UK contribution which is about 25-30% of the total for the southern most badly-afflicted parts of Norway, and about 15-20% for Norway as a whole.

At this point, it is well to remember that even in southern Norway not all lakes are fishless by any means. Many other factors of considerable importance are relevant: the local composition of the soils and rocks, the incidence of fish diseases, the effect afforestation has on surface-water acidity, the availability of heavy metals in the soil, and the preservation or destruction of spawning areas in the streams, to mention but a few.

Moreover much of the sulphur deposition in Norway comes from the contribution of so-called "background" sulphate at low concentrations; that is from airborne sulphate coming in from off the Atlantic, the origin of which may be partly natural (from dimethyl sulphide from oceanic plankton, for example), some may travel all the way across the Atlantic from America, and some small part may be of European origin which has travelled far out into the Atlantic before turning back.

Clearly changes in UK emissions are going to have only a modest effect where the background contribution dominates over the direct UK contribution. However, whilst accepting all these provisos, the UK and other western European countries do have an obligation to reduce their contributions to Scandinavia wherever this can be done reasonably.

To decide whether it can be done reasonably or not, the question arises, "If we reduce our emissions by x%, will the depositions be reduced by something of the same order (say within 0.7X to 1.3X%) and will the effects respond roughly pro rata?" The last bit of the question is very difficult to answer at present, and so I will ignore it! Nobody would be happy with the situation where a reduction of emissions by X% led to a reduction in deposition of something greatly less than X%; the money could be better spent.

The first bit of the question sets off a second question : "Am I concerned with short-term episodic depositions or only with long-term depositions?". The question is an important one because we know that in any one situation the uptake of sulphur into rain is so complex and depends on so many "non-linear" physical and chemical relationships that no simple relationship can be expected between how much sulphur is in the air and how much comes out in the rain at a specified site. As an example, when the concentration of sulphur in the air is high, raindrops may become saturated and may not carry out significantly more than when the airborne concentration is much lower. This means that single episodes will not simply reflect changing emissions. If this is so, is the story any different for depositions averaged over much longer times? I believe the answer is "Yes", as I will show later. And this is important because long term depositions seem to many to be what matters overall in the Scandinavian problem, even though short term episodes may sometimes have important consequences. Over a long period of time there appears to be an almost exact balance between the amount of sulphur deposited and the amount getting into lakes and rivers.

(At this point is is well to remember that sulphuric acid is not the only problem: nitric acid, weaker acids, released aluminium and other heavy metals are also important. But I choose to consider only sulphur species since most is known of these, they are dominant and to some extent they are symptomatic of the other species).

THE PHYSICAL PICTURE

We are going to construct a model that tries to reflect the major processes which go on in the atmosphere that help to determine the link between emissions and long-term depositions. Figure 1 shows these processes in a schematic way. Almost all the sulphur will be emitted as sulphur dioxide. Emission takes place from a wide variety of sources, some near the ground, others at 100 metres or more height. The wind carries the plume away downwind, and the probability distribution of wind-directions will be one of the most important bits of input data. The airflow will almost always be turbulent, and this is very important. It means the plumes will normally diffuse to fill the whole of the so-called mixing layer - a layer of variable depth which is anything up to about 2 kilometres deep. This mixing not only spreads some of the sulphur (we will use the term "sulphur" loosely to mean all related sulphur species) to ground level where it can be taken up by the surface - a process called dry deposition - but it also enables the sulphur dioxide to mix and be converted by oxidants of various kinds originally present in the surrounding ambient atmosphere to sulphate aerosol.

At some stage the plume may be drawn into the influence of rain clouds. Some of the "sulphur" may be washed out below cloud as the rain falls through the plume, although this process is not particularly efficient. More effective removal occurs when the sulphur is drawn into cloud and gets into growing droplets. The model will be very cavalier about all this - it cannot hope to treat the highly complex micro-physical cloud processes properly. Instead it will assume some rather simple, but broadly representative, empirical relationship between what is in the air and how much comes out in the rain. The justification for this is that "sulphur" appears to be very rapidly removed in rain at normal concentrations. Empirical evidence suggests the removal time is usually less than the typical duration of a rainy period, as evidenced by the "clean" look of the atmosphere after rain. It should be said that air-chemists find this rapid cleansing somewhat difficult to explain at present when they try to simulate the detailed behaviour of what is going on in cloud, which may suggest that some efficient uptake route has still to be discovered.

Overall, dry deposition exceeds wet deposition over most of Europe averaged over a long period of time. This is because even though rain is a very efficient remover of "sulphur" it occurs only about 7% of the time. In more remote areas, like northern Scandinavia, the reverse is true and the reason for this is that since the sulphur dioxide is gradually oxidised to sulphate the loss to the ground by dry deposition decreases (sulphate is only very slowly taken up by the ground) whereas, relatively, wet deposition increases (sulphate is more rapidly taken up by cloud droplets than SO_2).

The model we will develop will be a statistical model. It will describe the probability of there being a specified mix of SO_2 and sulphate left in the plume after a given distance (or time) of travel downwind of the source, and the implied wet and dry depositions associated with the mix. To help in this, we need to include information on how rain is distributed in time and space. Obviously the probability of rain is not the same everywhere all the time: rain is more likely near an active warm front than in the middle of a summer anticyclone. We therefore conceive the existence of dry regions (where the probability of rain is essentially zero) and of wet regions (where the probability is high). These regions move both relative to the ground and relative to plumes in the mixing layer. They have typical time-scales (we choose 40 hours for dry regions and 8 hours for wet regions based on studies following low-level trajectories) which determine the probability that an element of the plume will advect from a dry region into a wet region (or vice versa) in any short time interval.

Summing up over all possibilities (all conceivable mixes duly weighted by their probability of occurrence) yields the deposition field downwind of the source.

NON-LINEARITIES

It is generally agreed by scientists that dry deposition is proportional to the concentration of "sulphur " near the ground, when due allowance is made for the mix. Wet deposition may not depend so simply on the concentration, as we argued earlier. Normally one would expect that high airborne concentrations might not yield as much wet deposition in pro rata proportion as lower concentrations.

When a polluted plume enters a rain system it leaves a "footprint" of deposition. If the air concentration is rather low the footprint would be sharply peaked and subsequently fall off to near zero within a travel time of a few hours. If however the concentration is much higher, so that saturation effects occur, the early rain cannot bring down more than a certain burden and the footprint is extended out over a longer travel time or distance. Ultimately the integrated deposition must be identical to the airborne input: what goes up must come down! But where it comes down must change.

The basic qualitative argument is that if a receptor is sufficiently far away from the source, the variability in where rain occurs along the plume track means that on many different occasions the receptor sees all parts of the footprint and the time integrated deposition equates to the space-integrated area under the footprint which in turn equals the effective emission. The exact shape of the footprint (and thus the details of the non-linearities) then becomes unimportant. The relationship thus reduces to one of expected proportionality between emissions and depositions.

THE MODEL

The model solves the "conservation" equations for sulphur dioxide and sulphate in dry and wet regions separately. In the wet regions an extra term represents the removal by rain. The non-linearities associated with this process have been discussed in general terms above. Without a hugely complex physical/chemical model demanding input data which is partially unknown, these non-linearities cannot be precisely represented. Instead a very simple representation is made that carries the character and quality of the non-linearity. It is adequate to answer the question that is the theme of this paper. The representation says that wet deposition is equal to

$$WD = \frac{\lambda C}{1 + \epsilon C}$$

where λ is a constant washout coefficient, C is the airborne concentration and ϵ is a parameter representing the magnitude of the non-linearities. If $\epsilon = 0$ the process becomes linear but if ϵ is large the non-linearities are dominant. With concentrations C around 20 - 100 ug m^{-3} a value of ϵ of the order of 0.05 will produce a non-linear response in general accord to what is expected in reality: e.g. if C = 50 the wet deposition would be $(1 + 0.05 \times 50)^{-1} = 0.3$ times that if ϵ were zero.

The dry deposition rate is conventionally represented by the product of the concentration C and a deposition velocity v_e. The model does not explicitly carry sulphur dioxide and sulphate separately. Instead it allows for the conversion of SO_2 to sulphate implicitly by making the dry deposition velocity a function of time of travel to reflect the change in the mix. v_e grows smaller as more of the SO_2 is converted and asymptotes towards the deposition velocity for sulphate alone.

The conservation equations for total "sulphur" in wet and dry regions are solved using the ladder-technique illustrated in Figure 2. It is rather easy to see what is happening. The rungs of each ladder represent possible values of the concentration. Consider the "dry" ladder: at the source, the emissions when well mixed through the mixing layer produce a specified concentration C_o. During the first time step, dry deposition ($v_e = v_e(0)$) reduces the concentration until at the end of the step $C = C_1$. Some of the SO_2 has been converted to sulphate and v_e has fallen in consequence to $v_e(1)$. The process is repeated to produce C_2, $v_e(2)$, C_3, $v_e(3)$ etc. At the same time in wet periods the concentration falls, due to the combined effect of dry and wet deposition, at a faster rate from D_o (which is identical to C_o) to D_1 to D_2 and so on. During each time-step there is a finite probability that some material in dry periods will be advected into wet periods and vice versa. In the calculation this is represented by taking some specified fraction of the material at concentration C_i ($i = 1, 2, 3, ...$) and adding it to the amount of material at concentration D_j on the wet ladder, where D_j is the nearest concentration just below C_{i+1} in magnitude. Similarly some fraction of D_i goes to that at concentration C_k, where C_k lies between D_i and D_{i+1} in magnitude. For small enough timesteps this process is quite unambiguous and accurate. The calculations I have carried out have been done with a half-hour timestep and this is probably as big as one dare go. At the end of each timestep the total dry deposition DD(t) is given by:

$$DD(t) = v_e(t) \times \sum_i (A_i C_i + B_i D_i) \ \Delta t$$

where A_i is the amount of sulphur at concentration C_i on the dry ladder and B_i is the amount of sulphur at concentration D_i on the wet ladder.

Δt = the timestep length.

The wet deposition WD(t) is given by:

$$WD(t) = \lambda \Delta t \sum_i ((B_i D_i)/(1+\epsilon D_i))$$

All these simple calculations are carried out with great speed and efficiency on a small computer.

RESULTS

The results are shown in Figures 3 - 6. Figure 3 shows how the dry, wet and total depositions fall off with distance with typical values of the input parameters. In this Figure, and later Figures, the width of the plume has been constrained to remain within a single grid-square of width 127 km, a reasonable enough assumption out to 2000 km. Moreover sensitivity tests show that the qualitative deductions (and in many cases the quantitative deductions also) are remarkably robust to changes in the input parameters.

Figure 3 also shows the response of the depositions to a major mountain range, like the Norwegian mountains. This was an important aspect to include because wherever the rainfall field has marked differences from the norm it is conceivable that whatever conclusions we come to regarding the question of proportionality may be seriously perturbed there. We assume the mountains increase the duration of wet periods at the expense of dry periods and greatly intensify the average rainfall rate. We see in the Figure how this produces a sudden jump in the wet deposition on the upwind side of the mountains, but since the heavy rain soon washes out the sulphur, the wet deposition rapidly falls to its original pre-mountain range value. In the lee of the mountains the parameters return to their old values and a smaller reversed reaction is seen in the deposition signature. Note that the dry deposition curve is only slightly affected by the mountains. This implicitly assumes the mixing layer air can normally pass over the mountains and is not seriously blocked by them.

Figure 4 shows how the depositions respond to a 50% cut in emissions. The ordinate is the ratio of the new to the old deposition represented as a percentage. Within about 200 km the percentage is greater than 60% for wet deposition, implying a rather poor return for the expense of cutting emissions, but at greater distances all three depositions are surprisingly close to 50%; in fact there is even a small enhancement of benefit (i.e. the percentage falls below 50%) which is an inevitable consequence of the accumulated effect of the non-linear zone in the first 200 km.

Note that the dry deposition, although assumed proportional to air concentration falls slightly below 50% since the air concentration is itself influenced by wet deposition.

Figure 5 shows a very similar set of curves, except it now includes the effect of the mountain range. We see a marked response but the conclusion of near-proportionality is still maintained throughout.

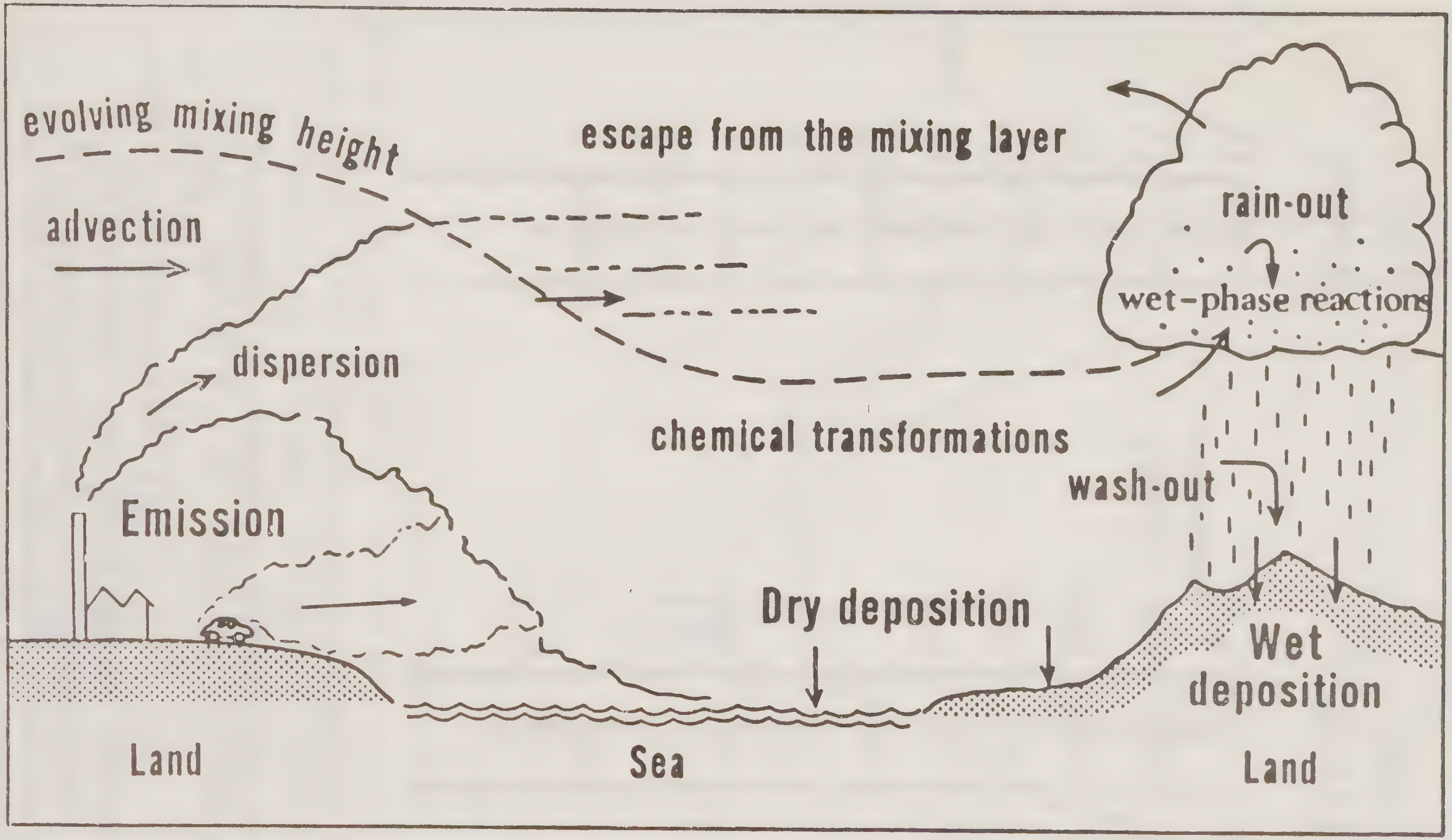
Finally Figure 6 shows how the ratio of wet deposition to dry deposition changes with distance away from the source when significant conversion of SO_2 to sulphate is taking place. The figure is for calculations assuming a zero deposition velocity for sulphate. When non-zero velocities are considered the curves are depressed, for example if $v = 0.2$ cm s^{-1} the curve for conversion rate = 2% per hour becomes close to that for 1% in Figure 6, and so on.

CONCLUSIONS

If the UK were to reduce its emissions in the future, it is unlikely that ecological systems, sensitive only to long-term depositions, within the UK itself would greatly benefit because non-linearities in the wet removal processes would generate non-proportional responses in the wet depositions.

However Scandinavia, at greater range, would be expected to see an almost proportional reduction in related depositions averaged over times in excess of a year because of adequate stochastic averaging. The Norwegian mountains would not be expected significantly to modify this conclusion.

The response of ecological systems to reductions in depositions requires further research, and such work should be continued with some urgency.



Processes involved in the deposition of atmospheric pollutants

Figure 1. A schematic representation of the various processes affecting plumes in the atmosphere.

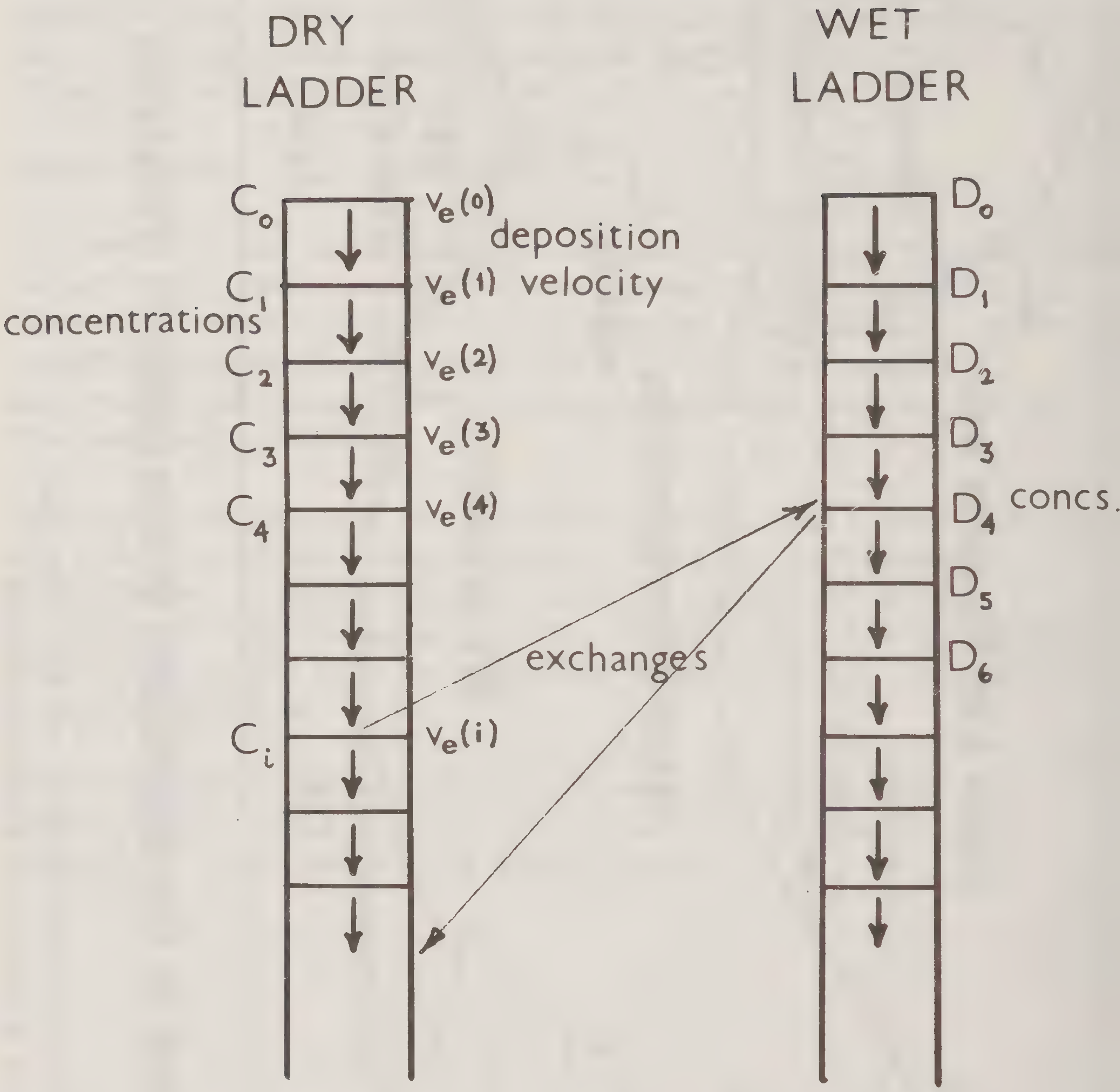


Figure 2. The two ladders by which the conservation equations for total sulphur in dry and wet regions are solved. The model incorporates the following processes: emission into wet and dry periods, dry deposition, wet deposition in wet periods only, chemical transformation of sulphur dioxide to sulphate, different deposition rates for the two species, transfer of matter between wet and dry periods.

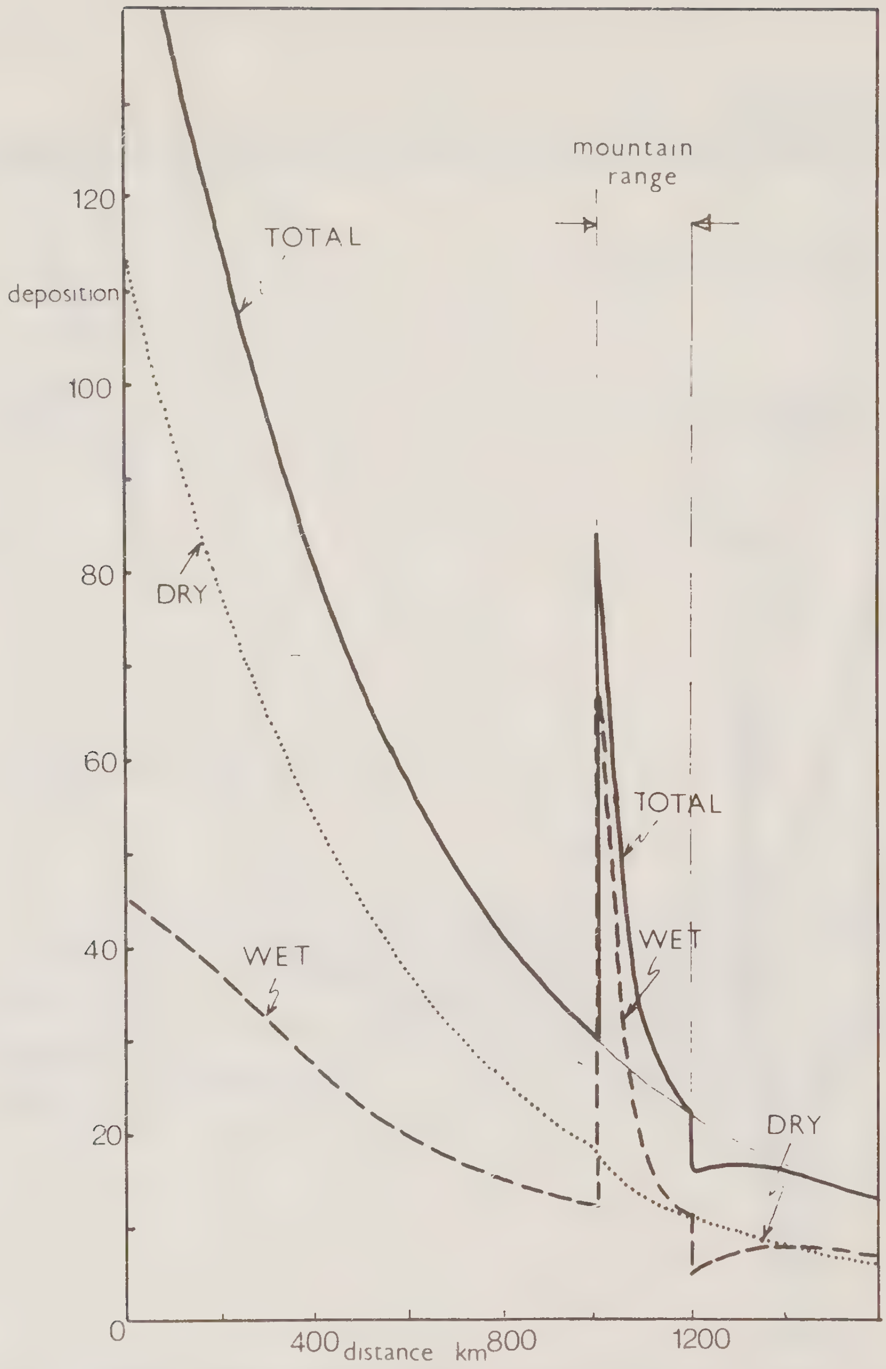


Figure 3. The variation of wet and dry (and total = wet + dry) with distance downwind from the source. A mountain range between 1000 km and 1200 km with markedly more rain causes an interesting perturbation to the wet deposition profile. Parameter values are as follows:

outside the mountains:

$C_0 = 50$ ug m^{-3}, = 0.05, $v(SO_2) = 1$ cm s^{-1}, $v(SO_4) = 0.2$ cm s^{-1}, $T_d = 40$ hours, $T_w = 8$ hours, conversion rate $SO_2 - SO_4 = 2\%$ h^{-1},

inside the mountains:

$T_d = 36$ h, $T_w = 12$ h, rainfall rate trebled.

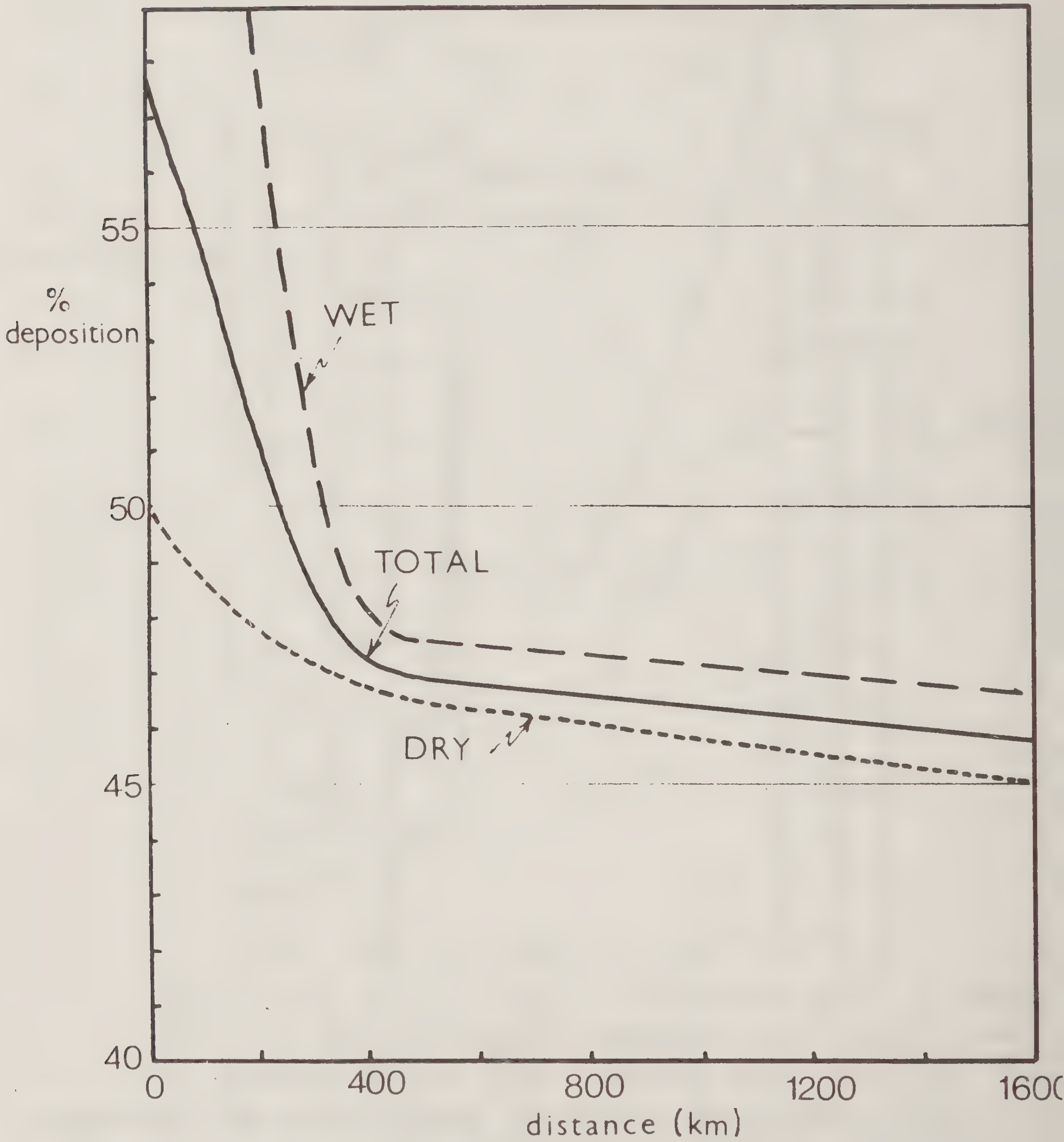


Figure 4. Percentage depositions resulting from a halving of the emissions showing how close these lie to 50%, the value if perfect proportionality existed. The initial concentration was halved from 50 ug m^{-3} to 25 ug m^{-3}.

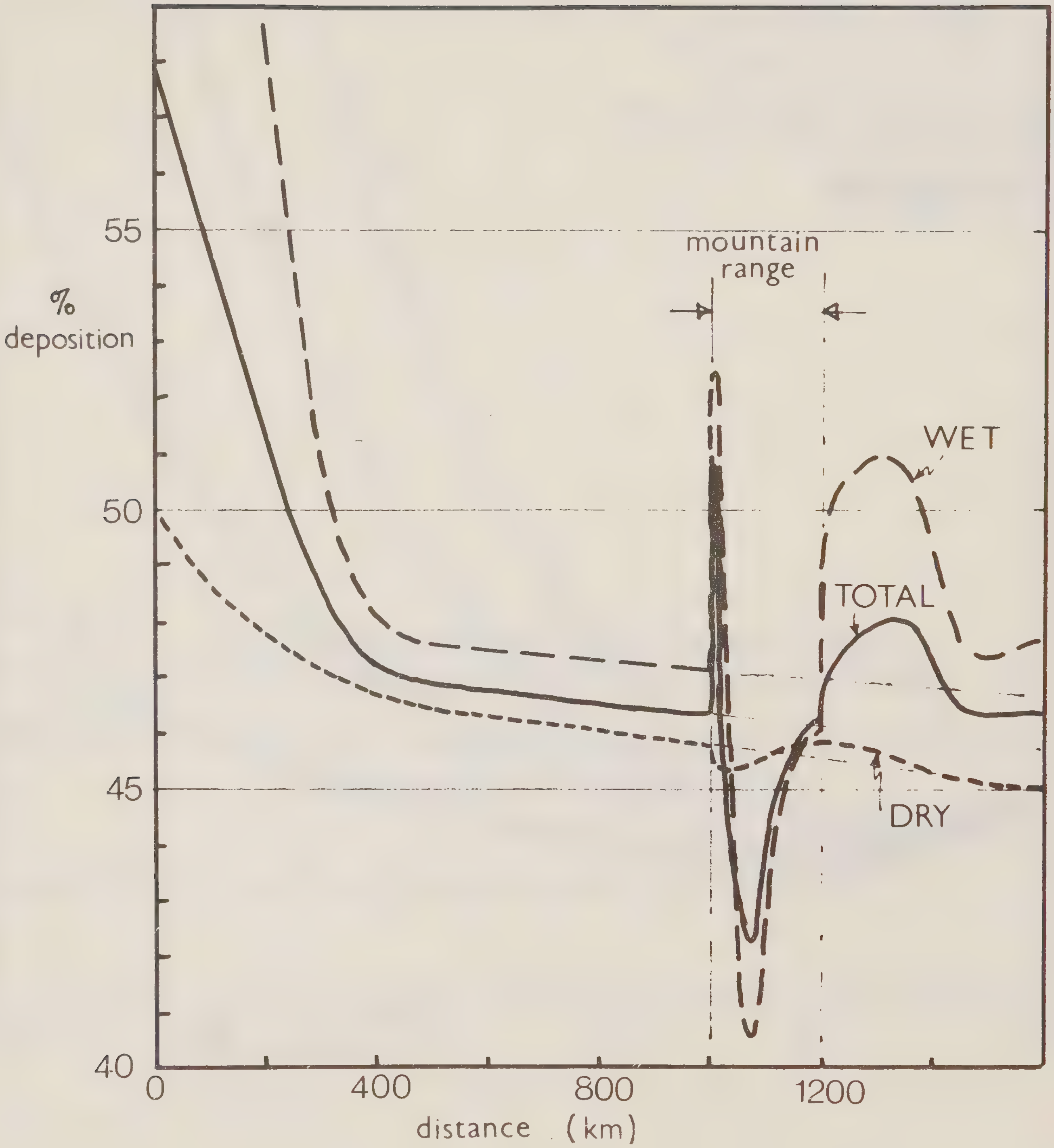


Figure 5. The same plot for the same parameter values as in Figure 4 but now with the influence of the mountain range described in Figure 3. Although marked perturbations are to be seen, proportionality is still virtually achieved.

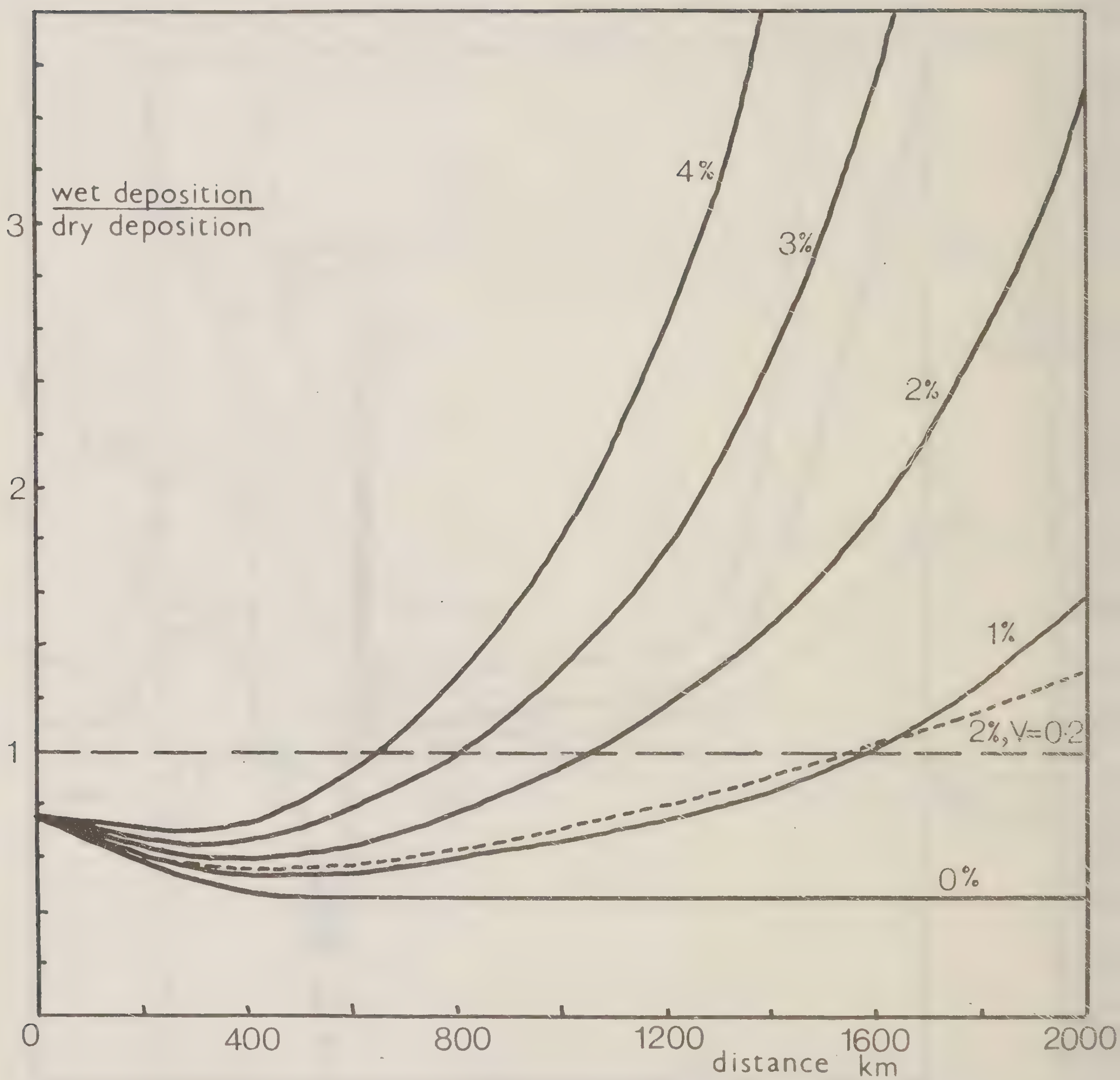


Figure 6. The ratio of wet deposition to dry deposition for various conversion rates of SO_2 to sulphate. Wet deposition begins to exceed dry at distances greater than a few hundred kilometres (the exact value depending on the conversion rate). The full curves are all for zero deposition velocity of sulphate; the pecked line is for a deposition velocity of 0.2 cm s^{-1}.

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– FURTHER PERSPECTIVES ON ACID RAIN –
EFFECTS OF ACID DEPOSITION ON UK BUILDINGS

– By –

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BACKGROUND

In 1984, the House of Commons Select Committee on the Environment produced a report on Acid Rain, in which the first effects to be considered were those on buildings. The report itself and the subsequent Government White Paper in response to the Select Committee report recommended and accepted lines of enquiry and research by certain public bodies in order to alleviate and eliminate the actual or potential problems. This presentation is a state-of-the-art report on the current situation in the United Kingdom by considering a series of questions. They are:

A) Is there a problem? If so where is the evidence?

B) What types of building are likely to be affected, how many are there and where are they?

C) Which building materials are likely to be affected?

D) What are the differences between "normal" and "abnormal" weathering behaviour of building materials.

E) Which pollutants in the air might affect buildings and what is known about rates of erosion?

F) Which current research activities and initiatives are addressing the above problems?

In the following discussion the above problems will be considered; there will however in this paper be an emphasis on masonry materials with some reference to other building materials.

A) Is there a problem?

There is in the sense that the products of pollutant reaction with for example stone are manifest and easily identifiable chemically. The real question is whether rates of erosion of building materials are greater in the presence of pollutants than in the absence of pollutants and also whether the rates of erosion resulting from acid deposition have increased significantly in say the last 30 or 40 years. Further comment on this question will be left until the end of the lecture. It is necessary, however, to define what is meant by acid deposition in the context of building materials. For the purposes of this lecture I am using the same basic definition as that used for "acid rain" in the Select Committee report, namely any form of deposition, dry or wet, arising primarily from the combustion products of fossilised fuel, and the further reaction of the combustion products. The Select Committee report gave as examples sulphur oxides, nitrogen oxides, sulphuric and nitric acids and other chemical compounds. In terms of a pH demarcation on what constitutes acid rain, although theoretically water saturated with carbon dioxide should have a pH of 5.6, the DOE Review Group on Acid Rain decided that after consideration of available data a pH of 5 would constitute a point on the pH scale whereby anything less would be considered to be acid rain. It should be pointed out at this stage that there will be background levels of acidic compounds in air which arise from natural sources. One compound in this context which sometimes is ignored in terms of the effect of acid deposition on buildings is carbon dioxide. The enhancement of levels of carbon dioxide in the atmosphere, particularly in urban environments, is one where there is a dearth of data available and which requires much more detailed consideration in future.

B) What types of building are likely to be affected, how many are there and where are they?

The first point to make here is that BRE are only considering the effect on the external envelope of a building. There will of course be some effects on the inside of a building if the outside levels of pollutants are sufficiently high, but the levels inside are usually very much lower. A major consideration of indoor pollutants is the effect on the valuable collections to be found within museums and art galleries. Such effects however will not be discussed in this presentation.

If we discuss the easier aspects first, namely stone buildings, those uppermost in the general interest at present are historic buildings, including cathedrals and churches. There is no real problem in establishing where such buildings are and what they are made of, although in many cases the situation is complicated by the use of different sources of material of different durability over periods of up to 900 years or so. One major difficulty, however, arises in assessing the cost of the damage to such buildings by natural weathering and by pollutant attack. In particular, one very difficult assessment necessary in any cost-benefit analysis of control options is how to assess the value of such buildings and also of monuments.

In terms of establishing an inventory of buildings and determining the stock at risk and the amount of different material say in a given geographical area, modern buildings pose a major problem. In principle, records of designs and specifications should be available, especially for public buildings, but ascertaining the whereabouts of such data for even one given urban area is a very difficult job. Two possible approaches to the number and material composition of the external envelope of buildings in a given location are the use of direct survey methods and of the predictive techniques based on factors such as land use classification. Both of these techniques are currently the subject of research activity in the UK and elsewhere and will be mentioned again in a later section of this lecture.

Modern buildings are structurally different from the older stone cathedrals and churches or timber frame buildings. On the smaller scale, modern buildings are mainly of brick or block, and brick or frame and panel construction. On the larger scale they are of frame construction, for example steel, concrete, with some kind of cladding on the outside consisting of concrete, stone, metal or plastic. There is also a variety of finish applied to modern buildings, for example paints, varnishes and protective coatings of various kinds. Materials such as glass, mastics, and slates are all features also of modern buildings large and small.

A potential source of information on the amount of material exposed to the atmosphere in the external envelope of buildings is the statistics of construction and of the manufacture and supply of materials used. Before any major effort is expended on investigating such data, however, it is perhaps of more use in the first instance to establish which materials will be affected significantly and whether there are forms of different materials which incur added costs in replacement over and above the material costs.

C) What building materials are likely to be affected and how?

The more obvious building materials likely to be affected by acid deposition are metals and calcareous stones (such as limestones, magnesian limestones, calcareous sandstones). There is also a possibility that glass, organic materials (some of which are "filled" with inorganic oxides) brick, cement, mortars, concretes also may be affected. Important features to be considered however in each case are the durability of the material in the absence of pollutants, to decide which factors are important in "natural" decay or weathering processes and how these processes are affected by the presence of pollutants or acid deposition. Apart from the chemical reactivity of metals (plus the passive protective layers formed on them in the atmosphere) and stones with acidic pollutants, there are other parameters to be taken into account in assessing potential damage such as the porosity of masonry materials, meteorological variables such as windspeed, relative humidity, levels and frequency of precipitation (and consequently how often the surface of a material is significantly wetted) and others. There will also be different mechanisms and sequences of events by which pollutants in different physical forms will attack building materials. In the case of a limestone for example, the possibilities include: (i) wet or dry absorption of pollutant gas followed by chemical reaction and dissolution of the products in rain water; (ii) direct dissolution of the stone in acidic rainwater (both of these operating on a relatively short time-scale); (iii) a much longer-term but equally important process in which reaction products more soluble in water than the original material (for example sulphates) move into the body of the stone where they can crystallise and form hydrates in expansive reaction leading to physical disruption of the stone surface and hence to decay.

D) The weathering behaviour of some building materials

MASONRY

Brick, and some building stones, are affected by frost, usually when the moisture content of the masonry is high for prolonged periods, and by transmission of soluble salts from the earth or from marine or other sources. The detailed mechanisms of damage by frost or salt crystallisation are not completely understood; there are some similarities and some differences. The expansion of ice with reference to the volume of water from which it is formed explains the bursting of uninsulated pipes and this mechanism will also have an effect in frost damage in brick and stone. The simple expansive reaction of ice, crystallisation of salts etc, is not the entire story of how stone decays. It is known for example that non-reactive materials absorbed into stone which do not undergo expansion on freezing (for example nitrobenzene) can still have an adverse effect upon freezing. Frost damage and salt damage to stone depend on the pore size distribution of the material, its chemical composition, and its mechanical properties. It is known that limestones which have a high percentage of very small pores in them are less durable than those which do not.

The physical manifestations of frost damage to a stone are somewhat different from damage by other mechanisms (salt damage - which may also originate from soluble reaction products of the original material with acid pollutant species in the atmosphere). Large sections of the surface of frost-susceptible stones split away after cracking from the bulk of those parts of stone buildings likely to be exposed and very wet (for example balustrades, parapets). Decay by acid attack on stone has the effect of removing detail in a fairly uniform way from, for example, detailed carvings by powdering or blistering the surface. Different types of stone have very different weathering characteristics and durability (for example magnesian limestones undergo what is called cavernous decay). Brickwork is affected indirectly by salts which move from the brick into the mortar joints causing expansive reactions. Salts in the bricks themselves cause the self-evident efflorescence. Little is known however about the likely effect of acid deposition on bricks and the extent to which weathering characteristics are affected, for example whether attack by acid deposition would change frost resistance.

METALS AND CONCRETE

The mechanism of weathering of metals exposed to the atmosphere is a complex subject and will not be discussed here in detail. For non-ferrous metals a degree of protection is achieved either by a surface finish or naturally by the formation of a passive layer, such as an oxide film in the case of aluminium or a basic carbonate in the case of copper. General corrosion of ferrous metals is prevented by surface finishes or galvanising or encasing in another material which provides passive resistance to corrosion. The design of reinforced concrete beams or panel members of buildings relies on passive resistance of ferrous metal (steel) by surrounding it with an alkaline environment. The problem arises when carbon dioxide from the air destroys this alkalinity by diffusing through the pores or cracks in the concrete giving rise to the phenomenon called "carbonation". This destroys the passive resistance and induces the normal corrosive processes in the steel in the presence of oxygen and water. Expansive corrosion of steel in concrete can give rise to mechanical damage by cracking.

The important consideration, as with all other material is how, if at all, and at what rate does acid deposition affect these natural weathering processes. In the case of some metals, passive resistance may be destroyed by sulphates, nitrates; galvanising may be removed at a higher rate than in the absence of acid deposition. For reinforced concrete the carbon dioxide in the atmosphere is already known to be a major factor in decay, but how would it be affected by increased carbon dioxide levels or by sulphate or nitrate attack? As far as concrete itself is concerned, sulphur dioxide will react to form a product "ettringite" which is stronger than the original material, and there will be some expansive reaction. In the case of stone, three ways in which weathering might be increased in rate were mentioned earlier, namely dissolution in rain of low pH, reaction to form salts which crystallise and cause damage inside the stone, or reaction to form soluble reaction products. The mechanism of decay of a wide range of these and other materials (glass, mortars, paints, plastics) are being studied extensively at present, especially in order to determine rates of decay and how they relate to the concentrations of acid species in the atmosphere.

In order to obtain estimates of cost of damage to buildings by acid deposition, a combination of how rates of decay relate to important variables such as pollutant concentration, time of wetness and the amount of material at risk is required. The amount of material in a given area can be determined by survey and other means. Accurate relationships between rates of decay and other parameters are termed damage functions and are usually determined in the laboratory together with some calibration against the relatively small amount of data from actual buildings or from exposure of samples to the atmosphere.

On actual buildings one of the characteristics of older stone buildings in the urban environment is the black crust containing the products of combustion of fossilised fuel, reaction products of stone with pollutants and general dirt. The blackness is generally noted where there has been no natural washing by rainwater, namely when the stone or other material is sheltered in some way. Relating laboratory experiments on rates of decay to the real life situation is not easy, but attempts are being made to do so via surface analysis of decayed stone from actual buildings and from fresh stone exposed to polluted atmospheres. The same is true for other materials such as metals and glass.

E) Which components in the air might affect buildings?

Since the Clean Air Acts of 1956 and 1968 and the Control of Pollution Act 1974, levels of pollutants (especially sulphur dioxide and smoke) in the urban atmosphere have generally decreased. The increase or decrease in general average is of little use in predicting the effects on a particular building or building material and for this reason it is necessary to monitor, where possible, materials behaviour and pollutant levels *in situ*. For very comprehensive analysis of the cause and effect relationships between acid deposition and its effects, continuous monitoring would be required which would indicate the presence or otherwise of high episodes of pollutant species which may be infrequent and of short duration in time. An advantage of continuous monitoring is that data on the sources of episodes of pollutant can be obtained. A practical disadvantage is the economic one, namely cost of the operation. Generally a compromise has to be reached where daily averages of pollutant levels are determined at a range of sites with continuous monitoring undertaken at the different sites over limited periods of time. Current monitoring activities will only give information about current levels of pollution species and rates of decay. Searching of area pollution data and of relevant archival data is one way of assessing historical levels of pollution and rates of decay. There are also practical methods of determining historical rates of decay in some buildings.

Acid species derived from pollutants in the atmosphere include sulphur oxides, nitrogen oxides, carbon dioxide and their derivatives in gaseous and particulate form (solid and liquid) together with chlorides, fluorides and others. The chemical reactions governing the transformation of sulphur or nitrogen compounds from the atmosphere into the forms in which they react with or are deposited on buildings are extremely complex and will not be discussed here. It is important to realise, however, that since the Clean Air Act, the chemistry of production of reactive species in the atmosphere will have changed in that the role of the increased levels of nitrogen oxide in the urban environment (from vehicle emissions) in the presence of sunlight, ozone, etc may have increased in significance although the effects on buildings may be indirect. In all cases much more information is needed about the concentration of different species to be found near or on the surfaces of buildings, the mechanism by which they react with or affect the decay of the different materials and how they combine with meteorological variables to give the measured rates of decay.

In the case of limestone, various possibilities of reaction with acid species in the atmosphere exist. Reaction with carbonic acid (rain plus carbon dioxide) will dissolve the stone and possibly reprecipitate calcium carbonate in a finer and more reactive form within the pores. Reaction with sulphur and nitrogen oxides will produce more soluble products which will dissolve in rainwater or, in the case of sulphates, more soluble than the original material but not readily soluble as would be the case with nitrate. Soluble reaction products can undergo cycles of solution and crystallisation within the stone pores, giving rise to effects on the stone long after the initial exposure to the pollutant species (a sort of memory effect). Such long-term effects make it difficult to relate currently observed decaying phenomena to current levels of pollution in the atmosphere.

It is also possible that some decay phenomena will arise in materials not normally associated with direct reaction with pollutant species. Porous media may absorb the calcium and magnesium salts which exist in rainwater and concentrate the metal ions to a level either where crystallisation phenomena occur or where reaction with acid pollutant species is possible.

The physical form of pollutant species and the rate at which they are presented to and absorb or react with building materials is important. Higher concentrations of acid species are found in finely divided liquid drops (fogs and mists) than in rainwater. Little is known so far about the significance of such different physical forms of presentation to a surface but research work is underway to establish data.

One crucial factor in the debate on the effect of acid deposition in a building is whether there is evidence to show that rates of erosion have increased or decreased in modern times and whether rates of erosion can be related to measured levels of pollution. Research at the BRE over a period of 10 years from 1955 to 1965 on samples of Portland stone in central London and at BRE indicated the absence of any linear relationship between weight loss and sulphur dioxide levels (weight loss ratios were BRE:London 1:2.5, sulphur dioxide levels 1:5 - 1:7 (winter) 1:6 - 1:12 (summer). Another interesting feature of these experiments was qualitative evidence of a link with rainfall. More recent work in Europe has established some correlation between the weight loss of fresh stone and pollutant concentrations measured using a device which related the uptake of soluble pollutant gases by a constantly wet non-reactive porous medium. Unfortunately, so far there has been no direct correlation of this measuring instrument with actual levels of, for example, sulphur dioxide determined by standard methods. Further research work for BRE has confirmed the lack of a linear correlation between weight loss and pollutant concentration. Laboratory experiments in the USA and elsewhere have established damage functions relating rates of decay with pollutant levels and other factors such as relative humidity and porosity but much more work is required to establish meaningful data.

Measurements taken *in situ* on St Paul's Cathedral and on fresh stone tablets exposed to the atmosphere in London and in other areas in the south-east of England by BRE have indicated:

i) an historical rate of decay of Portland stone at St Pauls of 0.078 mma^{-1};

ii) current levels of decay over a period of 5 years gave a maximum of 0.391 mma^{-1} and an average of 0.139 mma^{-1};

iii) estimates of rates of erosion from chemical species in rainwater after percolating down a vertical surface at St Pauls indicate a rate of 0.22 mma^{-1};

iv) rates of weight loss of tablets of stone exposed to wet precipitation compared to the weight loss achieved by similar tablets sheltered from weight loss but subsequently leached with distilled water of around 2:1, thus giving some idea as to the relative significances of wet and dry deposition of pollutant;

v) confirmation of the lack of a linear relationship between pollutant levels and rates of weight loss in limestones;

vi) there is evidence for a 25% greater weight loss of stones exposed to the atmosphere in London than in nearby rural areas;

vii) there is evidence that effects are directional with respect to the direction of prevailing winds.

There is some evidence therefore of contemporary erosion rates being greater than those over longer periods of time, but the data is very limited so that much more is required before authoritative statements can be made on this subject. Further, there is still also no clear evidence for the role of nitrogen oxides in the mechanisms of stone decay.

F) Research activities

There is at present in the United Kingdom a wide range of research activity being undertaken or planned, partly to resolve some of the unknowns mentioned earlier and to establish quantitative data, also in response to current international co-operative initiatives, mainly from the UNECE and the ECE.

The DOE/BRE have been or are currently involved in the following research work.

a) Monitoring of meteorological variables and pollutant concentrations on 9 or more buildings in the UK (including Wells Cathedral, Bolsover Castle, Lincoln Cathedral and some modern buildings).

b) Investigation of samples of stone and concrete already exposed to polluted atmospheres in the UK.

c) Investigation of the weathering of stone on St Paul's Cathedral; measurement of stone tablet decay alongside pollution levels determined by the IRMA device for NATO/CCMS.

d) Investigation of the weathering of stone on the west front of Wells Cathedral.

e) Investigation of the historic levels of pollution at Wells and Lincoln.

f) Determination of damage functions in the laboratory for a wide range of building materials and pollutants.

g) Investigation of the effects of fogs and mist on building materials.

h) Investigation of the different rates of decay of stone samples on a transect from the south-west to the north-east of England (following on a previous exercise for London and the south-east of England).

j) Seeking to establish data on the inventory and stock at risk of buildings in the UK.

k) Research on the problems of corrosion of metals in polluted atmospheres.

l) Investigation of the relationship between the durability of stone and physical properties (such as pore size distributions).

m) Modelling of air pollution movement.

n) Development of a decision analysis model for the effects of pollutants on building materials as well as on fish, trees, forests, etc.

Other initiatives on the monitoring of buildings on exposure trials and on laboratory studies are also being taken by the CEGB and the NCB, the former in a programme, part of which has been developed after discussion with the Cathedrals Advisory Committee for England.

National initiatives on this matter at present include review papers being prepared for presentation to the Watt Committee on Energy by a sub-group, the recent establishment of the DOE Building Effects Review Group to produce a state-of-the-art report and advice to the Department of the Environment in two years; the development of a UK national materials exposure programme under the guidance of BERG, part of which will then be used as a contribution to an international programme being master-minded by UNECE. International research initiatives include those by UNECE (the originator of the Convention on Transboundary Air Pollution) on updating of technical information, international collaborative work on effects of materials for which BRE will be the focal point in the UK, and the EEC is currently sponsoring research in Europe on this general topic. NATO/CCMS also initiated research in the past.

In a national or international programme differences in climate can be useful in sorting out the important variables (such as the relative importance of combinations of high pollution levels, precipitation, maritime or other location) and such variables must be incorporated in any future large-scale (geographical) research on decay.

G) Conclusion

The original question raised at the beginning of this paper asked whether there was a problem with acid rain on buildings and whether there was evidence for this. It is clear from the identification of reaction products of pollutant gases and other species in the atmosphere with building materials that there are processes taking place which would not otherwise occur. Much more work and research is needed before the critical questions can be answered reliably, notably whether the rates of such reactions have increased markedly in recent times and until more evidence is available for the detailed causes and mechanisms of these reactions and their rates, it will not be possible to predict the outcome of any control strategy.

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52nd ANNUAL CONFERENCE
14 – 17 OCTOBER 1985
SCARBOROUGH

– FURTHER PERSPECTIVES ON ACID RAIN – UK ATTITUDES AND OFFICIAL POLICIES

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1. Scope of Paper

2. Brief perspective of the problem:
   - Concern about local effects leading to bpm requirement for dispersal of emissions.
   - Identification of long range problem.
   - Present position and pressures - 30% club etc.

3. Government's dilemma:
   - Emission trends past and future.
   - Effectiveness of emission abatement.
   - Environmental problems of control.
   - Costs
   - Risks of growing environmental damage.
   - Political consideration at home and abroad.

4. UK and other countries' conclusions.

5. The future:
   - Research
   - Technologies
   - Energy use
   - International pressures.

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– AIR POLLUTION CONTROL – SITUATIONS REPORT – SMALL AUTOMATIC COAL FIRED BOILERS

– By –
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1. INTRODUCTION

The National Coal Board (NCB) is responsible for the mining and distribution of coal in the United Kingdom. For 1983/84 the saleable output of coal was 108.5 million tonnes, the principal market outlet being power generation (75.5 Mt). However, other significant uses were in the domestic (10.2 Mt), industrial (8.5 Mt) and coking sectors (7.4 Mt).(1)

A primary objective of the NCB's coal research programme for the domestic market is its concern to ensure that coal combustion provides an efficient, convenient, inexpensive and attractive means of home heating. To achieve this for solid fuel the factors taken into account in heating appliance design include the type of fuel burned, compatibility with the associated heating system, satisfactory heat distribution and control in terms of performance and the cleanliness of fuelling and removal of ash. The appliance must also be acceptable in environmental terms.

For market requirements up to about 13 kW (45,000 Btu/h) smokeless fuelled roomheaters and open fires are commercially available capable of full house heating at a thermal efficiency level above that set by laboratory test standards, for all conditions of domestic operation.(2) A range of heating appliances is also available which has been developed to burn high volatile bituminous coal using a simple combustion system operating on natural chimney draught.(2) These units burn a wide range of commercial house coal grades with a level of convenience, thermal efficiency and smoke reduction matching the corresponding smokeless fuelled appliances. They are also compatible with UK Clean Air Act requirements and can be sold into Smoke Control Areas.

There is now considerable interest in burning solid fuel to heat the larger private dwellings with heat load requirements in the range 17 to 45 kilowatts (60,000 to 150,000 Btu/h), because of increases in oil prices and the uncertainty of future supplies. Many of these dwellings are located outside natural gas supply areas and are served mainly by gas oil burning equipment.

Bituminous coal is a readily available fuel with a long-term availability and when burned cleanly and efficiently can give very competitive running costs compared with alternative fuels. However, this is a market sector demanding a very high level of automatic operation and control in appliance design and, to ensure market penetration, coal burning appliances are required of sophisticated form capable also of being fuelled and de-ashed automatically.

The potential for automated coal burning equipment is also considered to be high for the commercial market sector to provide heating for small commercial premises in the range 45 kW to 600 kW (150,000 to 2 million Btu/h). The total market size is about 28 million tonnes of coal equivalent of which gas oil use represents about one third(3) and the requirement is for both hot water boiler equipment and warm air heating. This significant market includes schools, local authority buildings, warehouses, small factories and hotels, etc.

Recent development work at the NCB Coal Research Establishment in support of these requirements has been toward the design of a coal burning underfeed stoker principle which is automatically self de-ashing. The paper describes the development and testing of novel designs based on this underfeed stoker concept offering the prospect of a fully automatic coal fired boiler (or warm air heater) range to replace oil fired systems in domestic and small commercial premises.

2. DEVELOPMENT OF SELF DE-ASHING UNDERFEED STOKER

2.1 Conventional Design

Solid fuel appliance types with automatic feed used traditionally in large domestic and small commercial market applications are anthracite fired gravity feed units and underfeed stokers which generally burn high volatile bituminous 'Singles' coal. The market potential for automated designs based on anthracite firing is difficult to predict as the future availability and relative cost of anthracite is affected by limited resources. By comparison, bituminous coal is a readily available fuel of relatively low cost where long-term supply can be guaranteed. Washed singles is supplied as a commercial grade of bituminous coal, sized 25 mm to 12 mm and is a low ash coal of relatively consistent quality. A typical analysis of a coal burned in underfeed stoker applications is given in Table 1.

Underfeed stokers of conventional design are used for installations from about 25 kW to 2 MW (7 million Btu/h) heat requirement. Singles coal is fed by a mechanically driven screw from a hopper or bunker to the base of a retort bowl containing the fire bed (Figure 1). Fan blown combustion air is supplied through tuyeres in the upper part of the retort and additional (overfire) air is fed above the fire bed to complete combustion, particularly of coal volatiles. In the conventional design an ash clinker pad is formed in the upper region of the retort as the coal is burned. This results in contamination of the fuel bed with ash and clinker after a few hours' operation and a reduction in heat output occurs. Manual removal of the clinker pad is necessary in order to recover the fire bed and maintain output. This factor inhibits the ability of the conventional design to provide high amenity in terms of continuous automatic operation.

2.2 Self De-Ashing Design

The self de-ashing underfeed stoker principle which has been developed by the NCB can, through its self cleaning action, give continuous operation without any reduction in heat output due to ash contamination and allows full automatic control to be applied. This is achieved through the use of a combustion system based on a circular, free standing retort which allows ash and clinker formed during combustion to fall from the retort into an ash container (Figure 2). The retort design incorporates special tuyere air port arrangements giving a shallow firebed with ash and clinker forming only on its top surface. An annular land surrounding the retort allows coke particles to be burned to ash before they reach and fall from the land edge. The fire bed is stabilised by the addition of an above bed heat reflecting arch or disc which increases local turbulence to improve smoke reduction, promotes even combustion of the shallow firebed and avoids the need for overfire or secondary combustion air.

Additional advantages which have been demonstrated for this very simple and compact design of underfeed stoker combustion system are a fire-bed of relatively low heat capacity which gives high flexibility in terms of combustion control and turndown (values of up to 30:1 being achieved) and the ability to be scaled up from unit sizes of 12 kW (40,000 Btu/h) to about 200 kW ($\frac{3}{4}$ million Btu/h). Also, coals of up to moderate caking properties can be burned satisfactorily.

3. DOMESTIC SIZE BOILER APPLICATIONS

3.1 Manufacturer Designs

A range of independent boiler designs has been developed in collaboration with heating appliance manufacturers, suitable for heating the larger domestic premises and incorporating the self de-ashing underfeed principle. The basic unit is in the form of a 'twin-tub' arrangement with the fuel hopper located adjacent to the combustor/boiler (Figure 3). Coal is fed by a short screw arrangement from the hopper to the retort. This design is suitable for properties where siting of a large coal bunker near to the appliance is inconvenient. The 'twin-tub' arrangement allows good flexibility in terms of appliance siting and utilisation of existing chimneys. Typical installations can be in kitchen, utility room, boilerhouse or garage situations.

Refuelling of the hopper and ash removal in the basic boiler units which have been developed is manual, both operations being carried out at the same time. The hopper holds about two days' supply of coal when operated under winter conditions and at least one week's supply during summer running. The boiler flue ways are in the form of single pass vertical smoke tubes or slots. This allows the use of chains or rods which can hang through the flue ways and be mechanically agitated or reciprocated through the occasional use of an external level to keep boiler heat exchange surfaces clean. The lever can be actioned manually or automatically. Clean and convenient ash handling is provided by the use of closeable metal ash containers in which the hot ash is cooled. A special design of dustbin lid allows clean tipping of cold ash into a plastic bag for ease of disposal.

3.2 Field Trial Models

Manufacturer versions of the basic twin-tub, independent boiler design, in the range 17.5 kW to 50 kW, have been on field trial for the last three heating seasons and include both kitchen and boilerhouse models. The smaller boiler designs feature a centreless coal feed screw arrangement. This allows miniaturisation of components with appropriate savings in capital cost. A total of forty boiler prototype units representing seven designs from five manufacturers is currently being field-trialled throughout the United Kingdom burning a range of singles coals. The users have demonstrated the reliability and flexibility of the firing system through continuous operation of the units, in particular for low load running during the summer months to provide domestic hot water only. This facility is possible through the form of combustion control and the high turndown ratio available.

Where site conditions allow, alternatives to the basic 'twin-tub' design can be used having large bunker facilities close to the appliance. Coal is then fed by screw direct from the bunker to the burner. In addition, a 'heat house' version by one manufacturer, Holden Heat, has been field trialled. This consists of a metal boilerhouse containing the boiler and control equipment, a two-tonne coal bunker, a mechanical screw ash disposal system and an integral metal chimney. The unit is delivered as a freestanding package and only requires connecting to the water and electricity supplies.

Commercial designs of 'twin tub' boiler from three manufacturers are currently undergoing approval testing for thermal performance and smoke reduction.

3.3 Smoke Control

Observations on smoke emission at sites has indicated virtually smokeless operation for the various designs. This is supported by laboratory measurements on smoke emission which have given values well within those permitted by clean air legislation. All solid fuel appliances used within Smoke Control Areas must be capable either of burning an authorised smokeless fuel or be appliances designed specifically to burn bituminous coal to give an acceptable degree of smoke reduction. Such appliances are termed 'exempted fireplaces' and the self de-ashing underfeed stoker range will be expected to fall within this category. The maximum permitted level of smoke emission to which an 'exempted' bituminous coal fired appliance must conform depends on the useful heat output given by the appliance. This information is summarised in Table 2.

The relevant laboratory test method is given in British Standards publication PD 6434. An 'exempted' appliance must also have met the relevant Domestic Solid Fuel Appliance Approval Scheme.

3.4 Operating Costs

The majority of underfeed stoker fired boilers on field trial have replaced oil fired boilers and in these cases improved comfort conditions with significantly reduced running costs have been reported with savings of up to 50 per cent being achieved. Figure 4 gives comparative heating costs expected for coal and gas oil for the domestic boilers sizes indicated. The graphical information given is based on January 1985, average coal merchant prices for singles for the London and Leeds areas and a single UK price for gas oil and relates to hot water boilers with gross thermal efficiencies of 70%.

It is estimated that in non-gas connected areas there are over 350,000 domestic oil-fired central heating systems.(4)

4. BOILER APPLICATIONS FOR THE COMMERCIAL MARKET SECTOR

4.1 Boiler Requirements

Advantage has been taken of the ability of the underfeed stoker design to be scaled up, to develop with manufacturers a range of higher output units up to 150 kW ($\frac{1}{2}$ million Btu/h) single burner rating suitable for application in the commercial sector heating market. Figure 5 gives the size and pattern of fuel use for this market based on 1980 sources of information and indicates a significant potential for coal to replace oil.(3) Comparative heating costs, given on the same basis as those for Figure 4, are indicated in Figure 6.

It is essential for this market application that solid fuel packages are provided which approach oil firing in terms of level of amenity and unattended operation. Such automatic boilers will incorporate large modular bunker facilities and automatic means for ignition and ash disposal.

4.2 Automatic Ash Disposal

A recent development to improve ash disposal enables ash to be removed automatically from the boiler using the suction available from a domestic vacuum cleaner. The automatic system has two principal parts. The first removes sized ash mechanically from the boiler and stores it in a reservoir, the second takes ash from the reservoir and transfers it pneumatically to a convenient ash store e.g. skip or plastic sack.

The mechanical ash removal system is shown schematically in Figure 7. Ash and clinker falls by gravity from the de-ashing retort and drops into a trough at the base of the boiler where a specially designed removal screw is fitted. The screw transfers the ash and clinker also crushing it at the same time to below 10 mm size. The crushing action is important as some clinker pieces can be large and would block subsequent pneumatic transport lines.

The screw feeds the sized ash into a collecting reservoir which has sufficient capacity for about 12 hours boiler operation. During the period of crushing and transfer the ash cools to room temperature. The reservoir is of special design to ensure that ash can be sucked out when vacuum is applied.

In the second operation, sized ash is sucked from the reservoir and transferred through low cost 35 mm diameter plastic pipe (of the type used normally for kitchen and bathroom waste water) to a special design of disposal unit where it is dropped into a plastic container or skip.

The design of the ash drop-out unit and its action is shown schematically in Figure 8. Basically, the unit is in the form of a cyclone separator which incorporates a cone valve which is self sealing when vacuum is applied. This allows coarse ash to drop out within the cyclone body and any fine ash to be collected on a filter bag which is connected to the cone valve. When the vacuum is released the cone valve drops shaking the filter bag clean and the ash falls into a plastic container.

This type of system has been fitted to a 25 kW field trial boiler and operated satisfactorily over a period of eight months. Ash disposal is effected automatically with the vacuum cleaner being operated by a time switch for about two minutes, twice a day. The system can transport ash for horizontal distances in excess of 15 metres, including a vertical lift of 4 metres, enabling the ash to be transferred to a convenient disposal point remote from the boiler, even if the boiler is located in a cellar. Figure 9 shows schematically an automatic ash disposal arrangement linked to a 150 kW self de-ashing underfeed stoker fired boiler.

The automatic ash disposal system complements the self de-ashing stoker/boiler design to provide the basis for fully automatic, solid fuel boiler packages. To ensure viability, capital cost has been an important consideration during development.

4.3 Manufacturer Developments

Several manufacturers are collaborating with NCB in the development of automatic boiler designs in the size range 50 kW to 300 kW, (150,000 to 1 million Btu/h). One manufacturer is also developing a parallel range of warm air units. Designs up to 150 kW rating are based on a single retort burner, the 300 kW designs having twin retort burners. Some retort designs feature rotating lands which can increase the range of coals burned. Most of the designs are expected to incorporate modular bunker arrangements, automatic ash disposal and electrical ignition.

Automatic boiler and warm air unit packages suitable for commercial sector applications are expected to become available commercially during Autumn 1985.

5. 'COALFLOW'

The Solid Fuel Advisory Service (SFAS) and the NCB is introducing a comprehensive range of services aimed at potential users. This is in support of manufacturers' new boiler designs based on the self de-ashing underfeed stoker concept. The boiler range will burn selected small size Housecoal which may include 'Pearls' which has a size grading of 12 mm to 6 mm. (The use of 'Pearls' is likely to improve the viability of small scale, automatic coal handling systems based on pneumatic transport. Initial combustion tests on a range of 'Pearl' sized coals appear satisfactory).

The new service will carry the name 'Coalflow' and is expected to include the following:-

i. Every phase of the installation, operation, fuelling and service of a Coalflow system will be controlled from a single location so that, for contact, customers will need just one address and one 'phone number.
ii. The Coalflow fuel supplier is trained to anticipate the needs of each of his customers and to ensure that the right quality Housecoal is delivered, regularly and reliably, at the right price.
iii. A Coalflow finance plan will encourage customers to pay for their fuel supplies on a monthly basis, spreading higher winter running costs across the year.
iv. Skilled maintenance engineers will be available to ensure that the mechanised Coalflow system keeps operating at maximum efficiency at all times.
v. A 24 hours-a-day, emergency support service will be available, all year round.

A pilot scheme is shortly to be introduced in the Midlands and if successful will be extended nationwide.

6. CONCLUSIONS

A new range of small automatic coal fired boilers has been described based on an NCB self de-ashing underfeed stoker development and suitable for large domestic and small commercial premises with heat requirements ranging from 17 kW to 300 kW. The boilers burn low cost small size bituminous coal at high thermal efficiency and with acceptable smoke reduction. Domestic boiler sizes will be able to comply with Clean Air Act requirements and can be sold into Smoke Control Areas.

Boiler designs aimed at the commercial market sector will include modular bunker arrangements, automatic ignition and ash disposal and will be very competitive with oil fired systems in terms of significantly reduced operating costs and equivalent level of automatic operation.

An SFAS/NCB 'Coalflow' service scheme is being introduced in support of boiler sales.

ACKNOWLEDGEMENT

The paper is published by permission of the National Coal Board and the views expressed are those of the author and not necessarily those of the NCB. Acknowledgement is gratefully made to colleagues, associates and to manufacturers involved in the activities described.

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Presentation to Watt Committee on Conversion to Coal in Industry, Commerce and the Home. 7 June 1983
3) Private Communication - National Coal Board Operational Research Executive, December 1983.
4) Private Communication - National Coal Board Operational Research Executive, December 1984.

Typical analysis of singles coal burned in self de-ashing underfeed stoker

1.	**Proximate Analysis**	
	Moisture (as analysed) %	10.5
	Ash (" ") %	4.6
	Volatile Matter (" ") %	34.6
	Fixed Carbon (" ") %	50.3
	Volatile Matter (dry ash free) %	40.8
2.	**Coking Properties**	
	B.S. Swelling Number	2
	Gray-King Coke type	D
3.	**Calorific Value**	
	Gross C.V.	
	Btu/lb (d.b.)	13760
	KJ/Kg (d.b.)	32000
	Btu/lb (d.a.f.)	14500
	KJ/Kg (d.a.f.)	33720
4.	**Ash Fusion**	
	Deformation Temp. °C	1140
	Hemisphere Temp. °C	1180
	Flow Temp.	1310
	Atmosphere	Reducing

TABLE 1

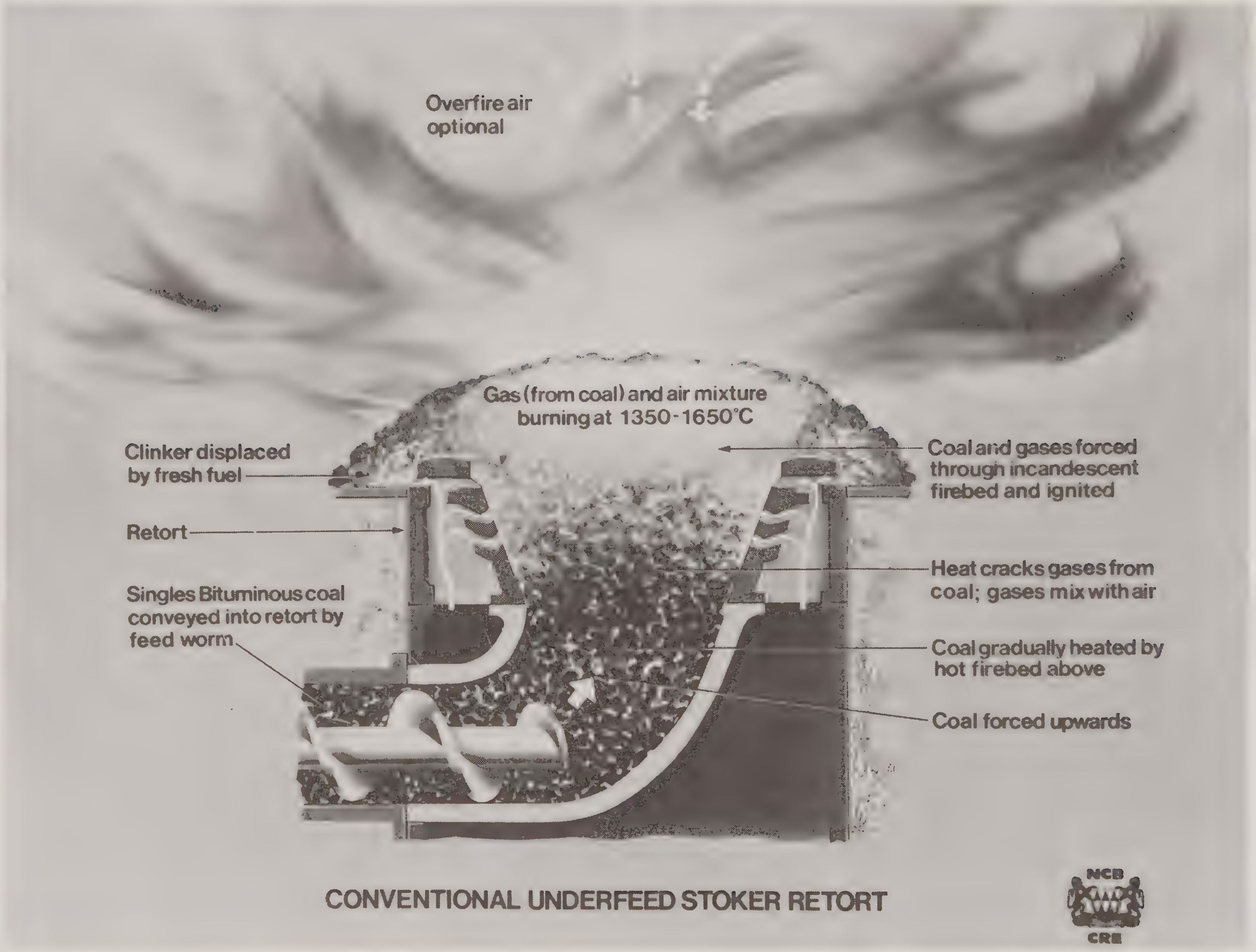
Appliance operating at kW	3	6	12	18	24	30	45
Appliance operating at BTU/h x 1000	10	20	40	60	80	100	150
Permitted smoke g/h	6	7	9	11	13	15	20

PERMITTED SMOKE EMISSION (SMOKE REDUCING APPLIANCE)

NCB.CRE

British Standard Recommendation PD 6434

TABLE 2


Overfire air optional
Gas (from coal) and air mixture burning at 1350-1650°C
Clinker displaced by fresh fuel
Coal and gases forced through incandescent firebed and ignited
Retort
Heat cracks gases from coal; gases mix with air
Singles Bituminous coal conveyed into retort by feed worm
Coal gradually heated by hot firebed above
Coal forced upwards
NCB
CRE

CONVENTIONAL UNDERFEED STOKER RETORT

FIGURE 1

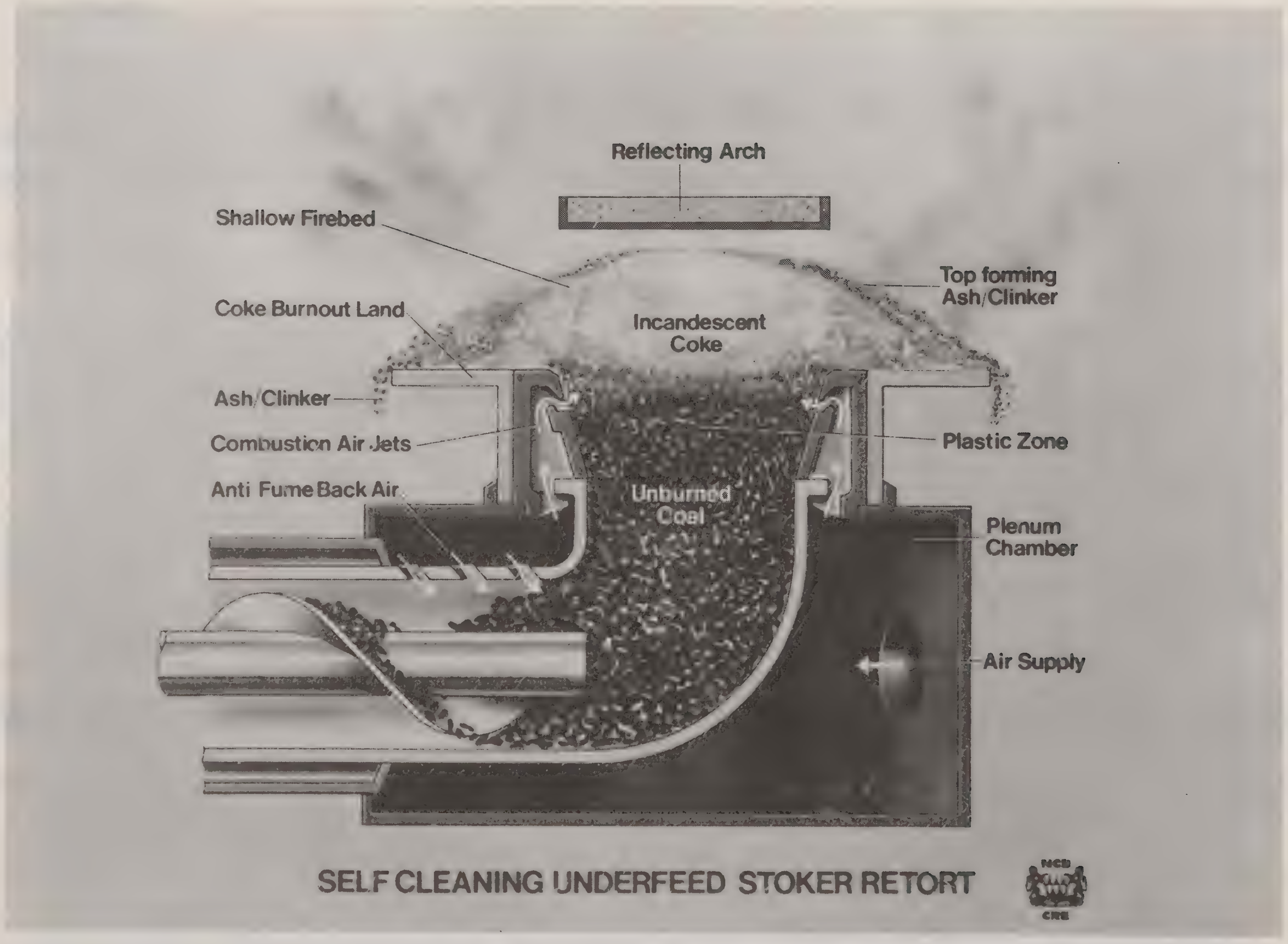
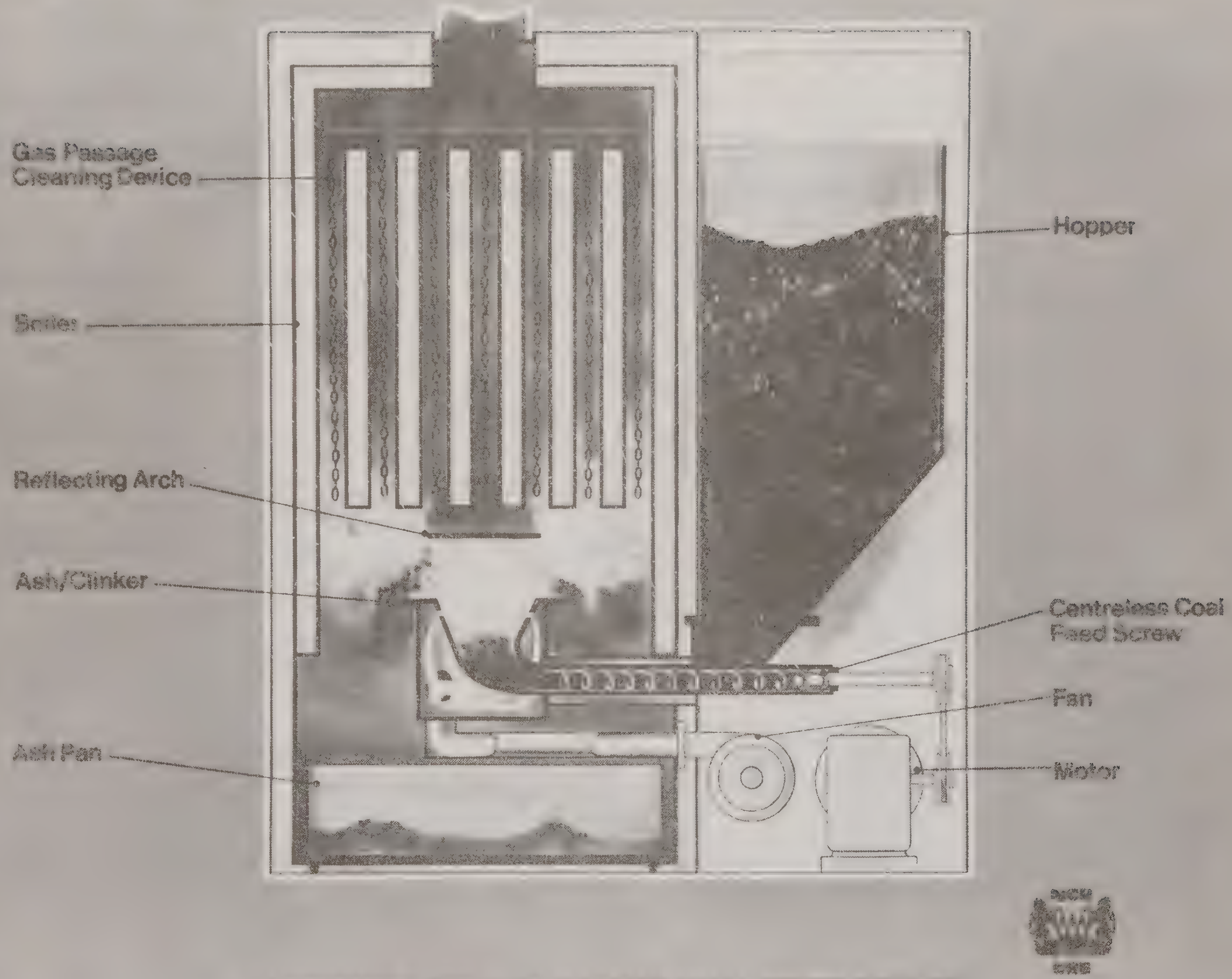


FIGURE 2

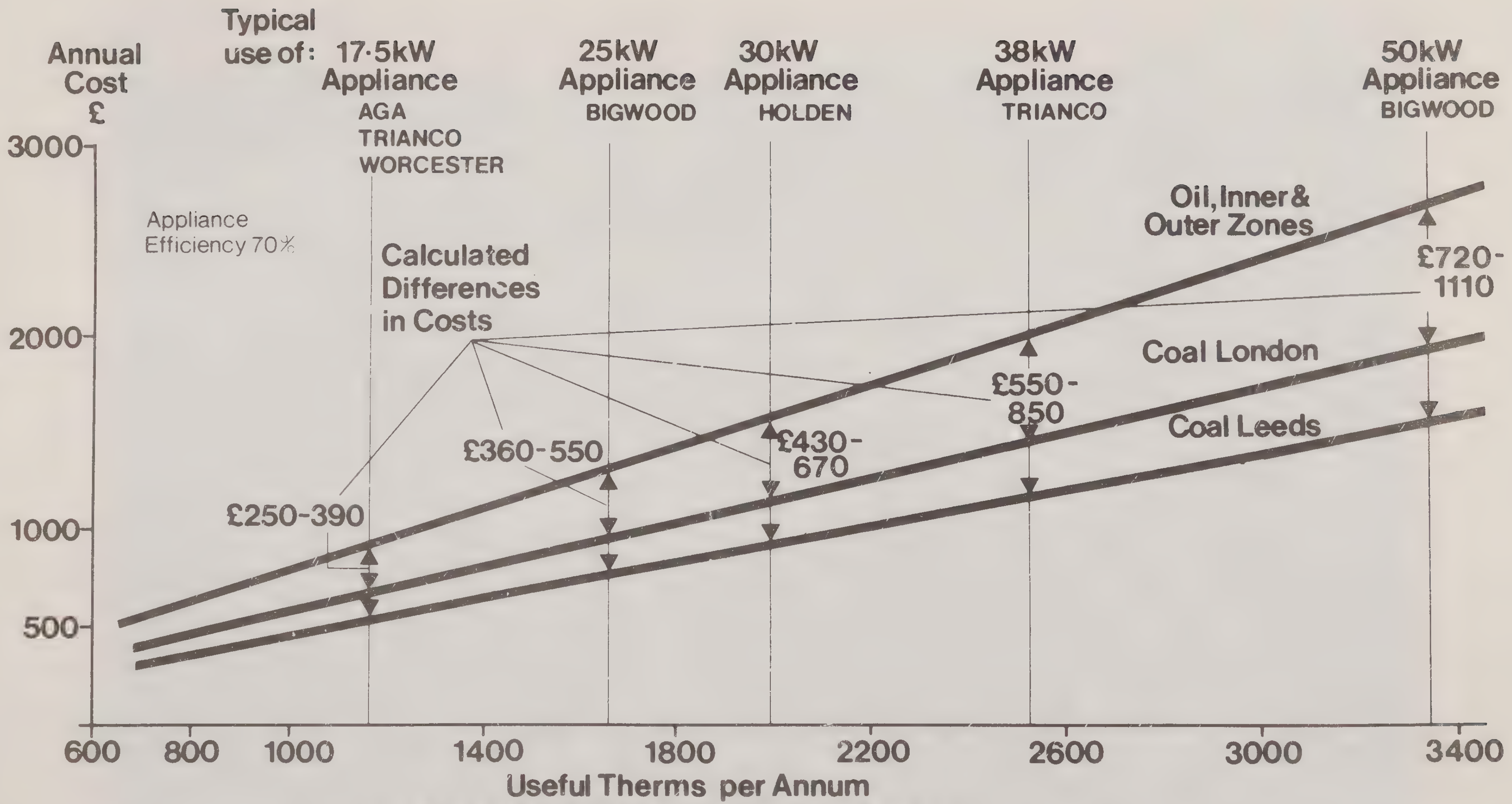
Patent applied for



AUTOMATIC SELF-CLEANING COAL FIRED BOILER

FIGURE 3

Patent applied for

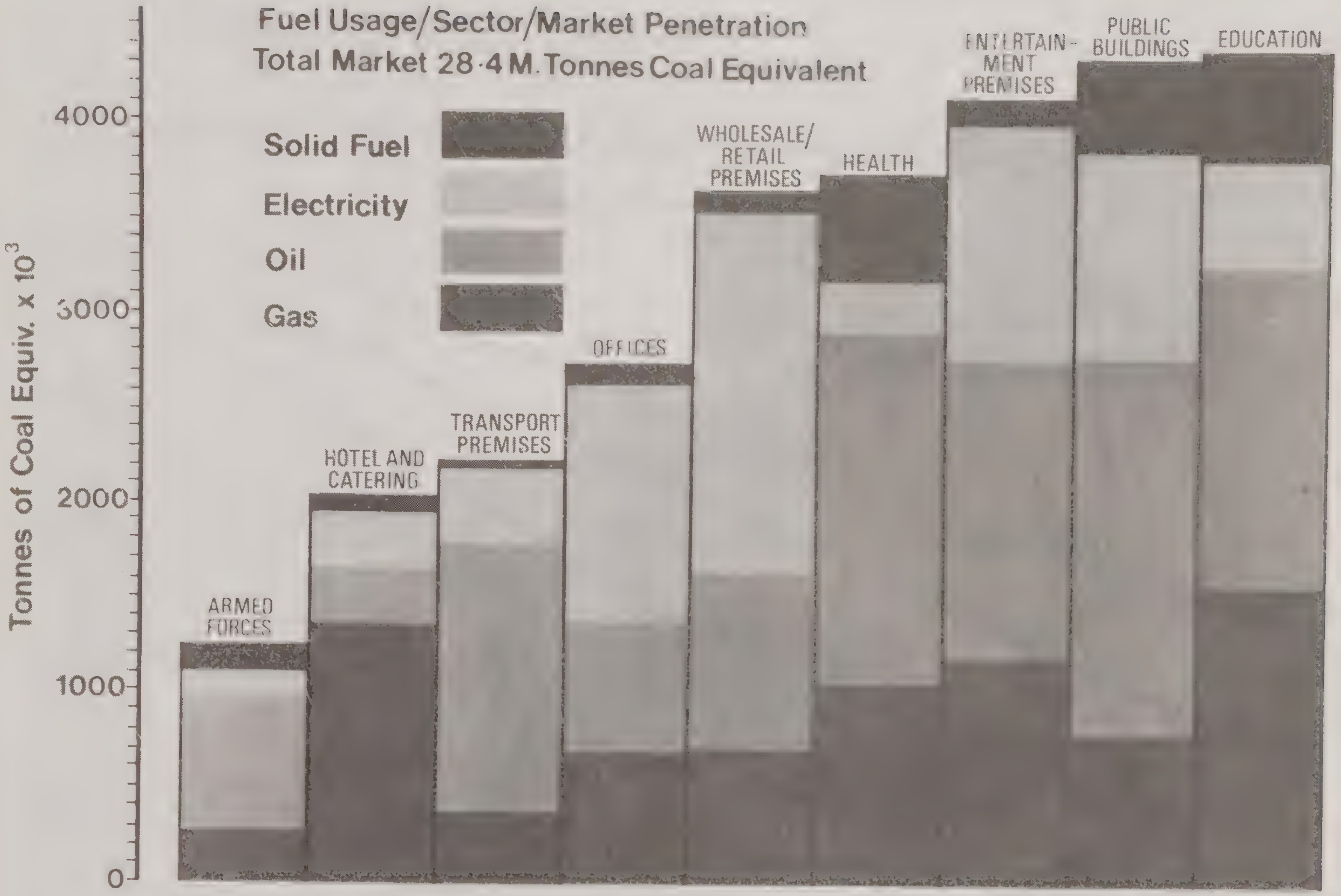


COMPARATIVE HEATING COSTS
DOMESTIC/COMMERCIAL SECTOR - JANUARY 1985

OIL (35sec. viscosity) delivery to 1200 litre storage tank. 79·4p/useful therm
Coal prices for major UK centres. 45·7 to 57·4p/useful therm

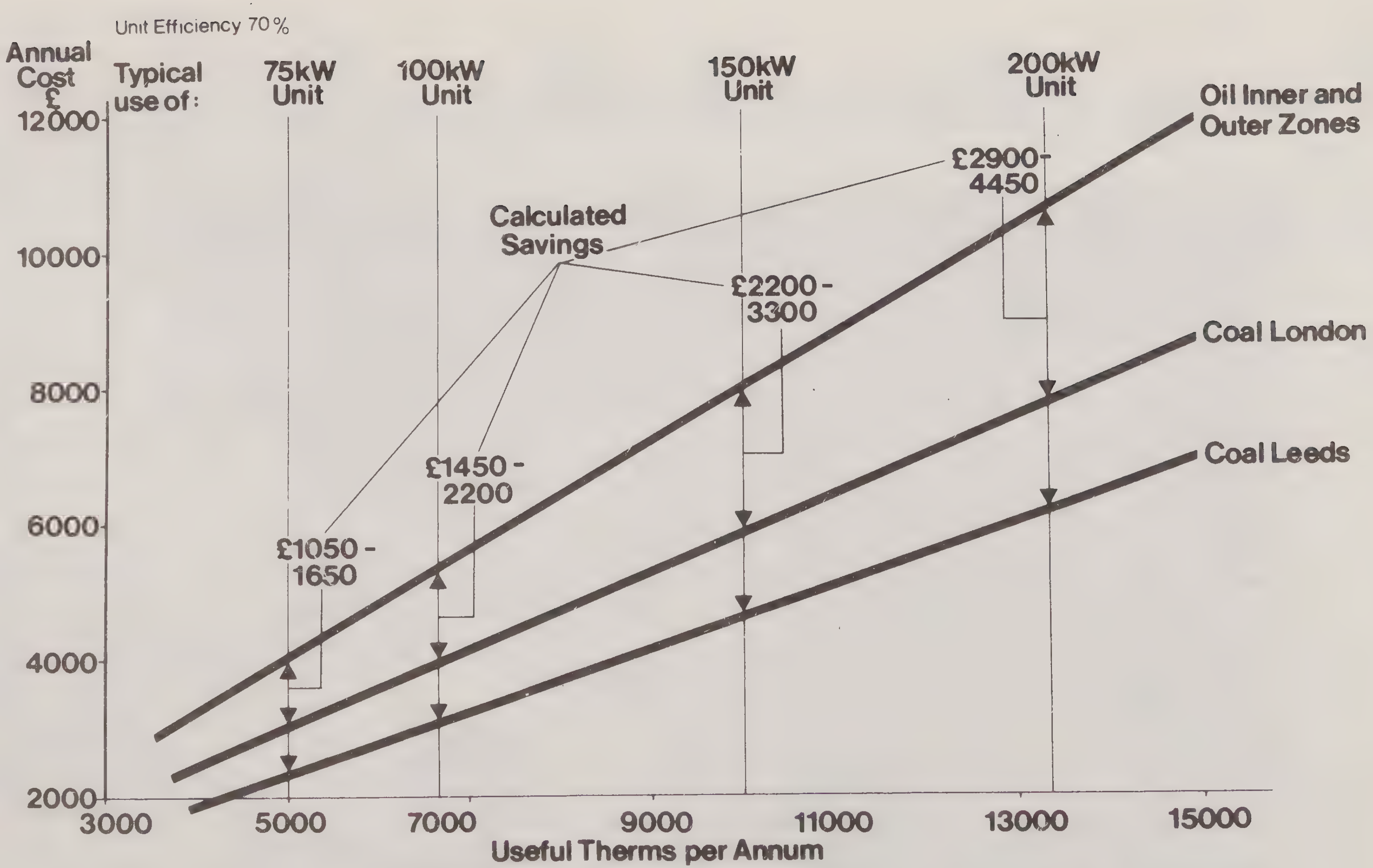
Source ———————— NCB

FIGURE 4



PUBLIC SECTOR & COMMERCIAL ENERGY MARKET — 1980 NCBCRE

FIGURE 5



COMPARATIVE HEATING COSTS – COMMERCIAL SECTOR JAN. 1985

Oil (35 sec viscosity) delivery to 5000lt storage tank 79·4p/useful therm
Coal prices for major UK centres 45·7 to 57·4p/useful therm

Source ———————— NCB

FIGURE 6

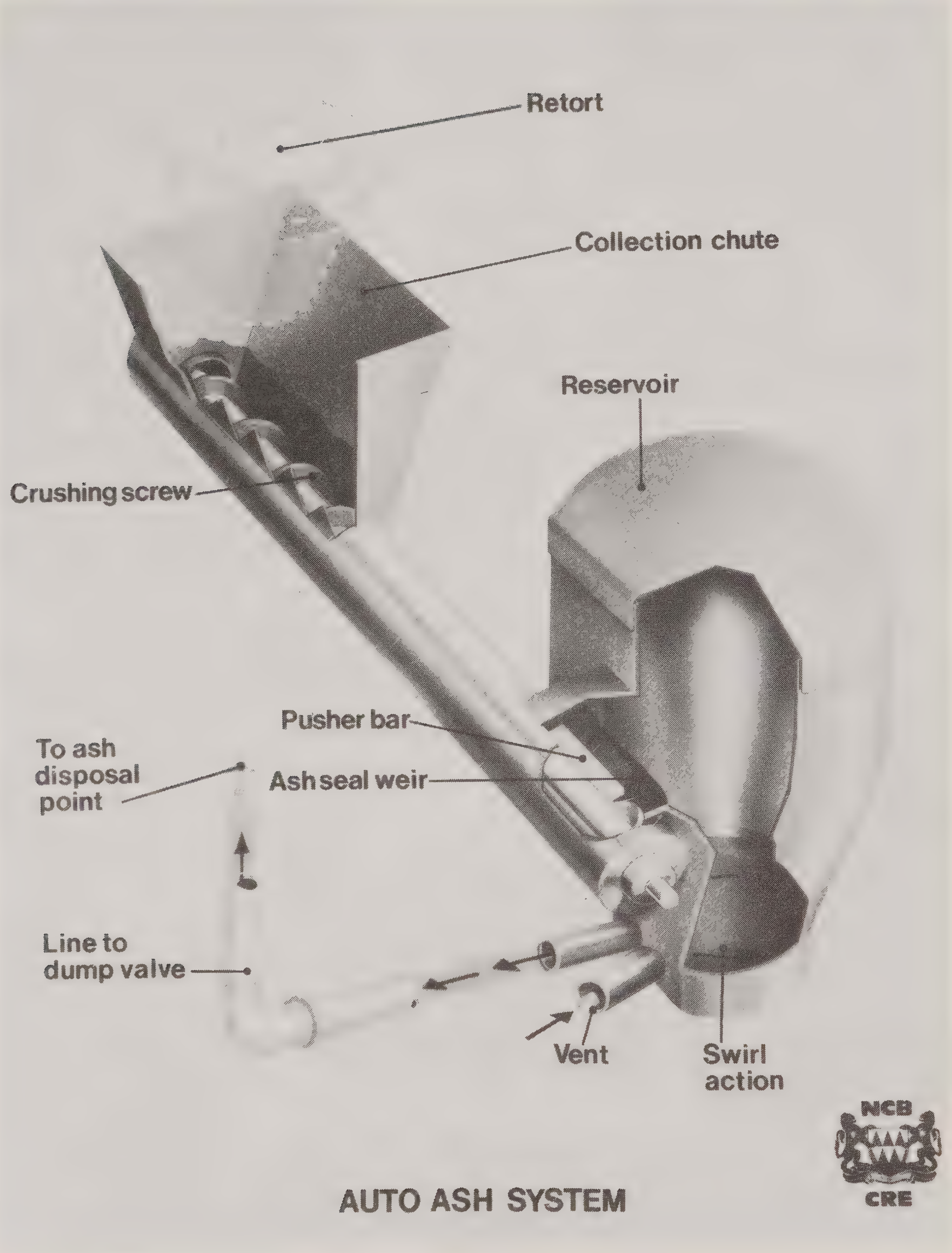


FIGURE 7

Patent applied for

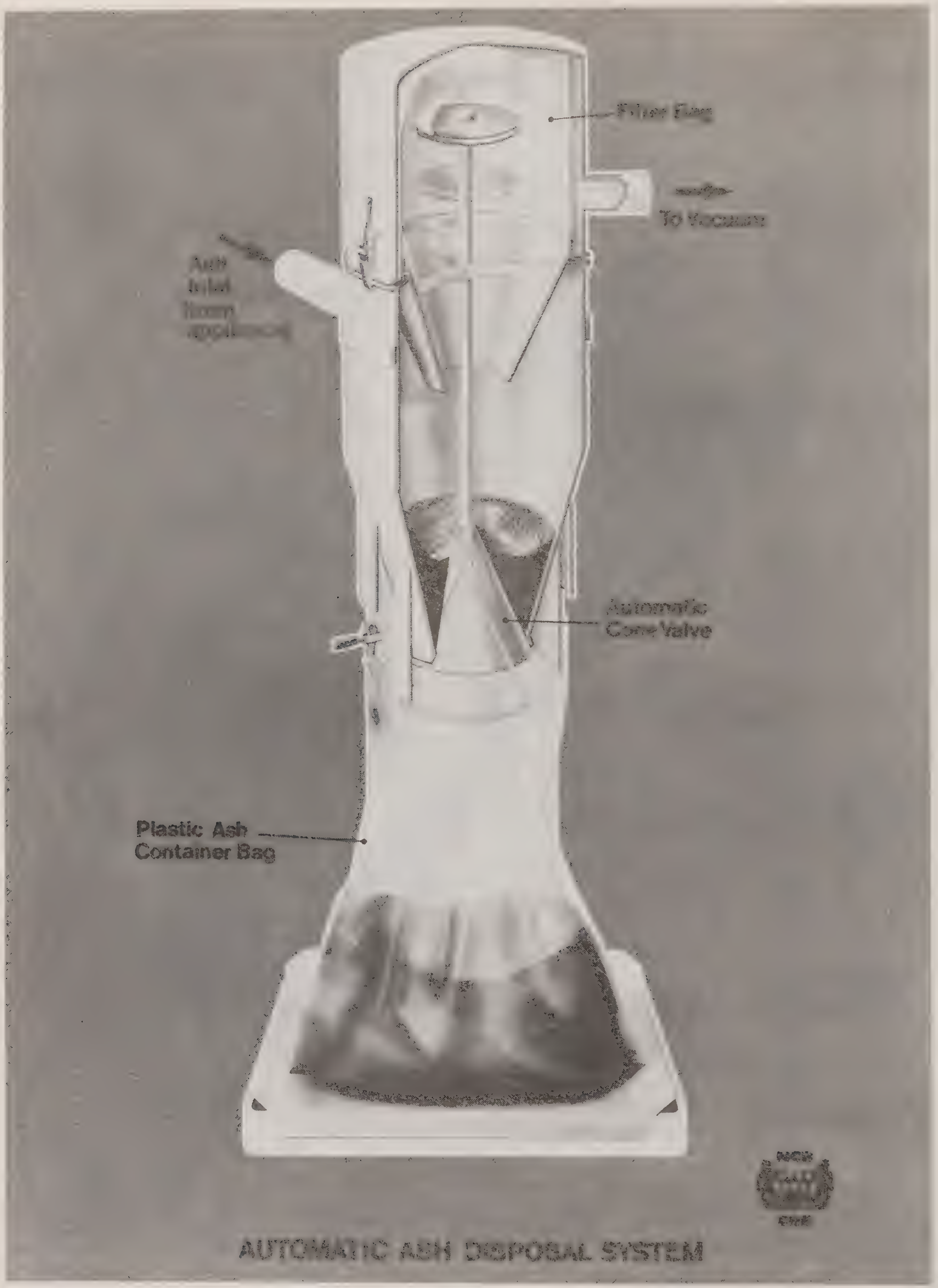
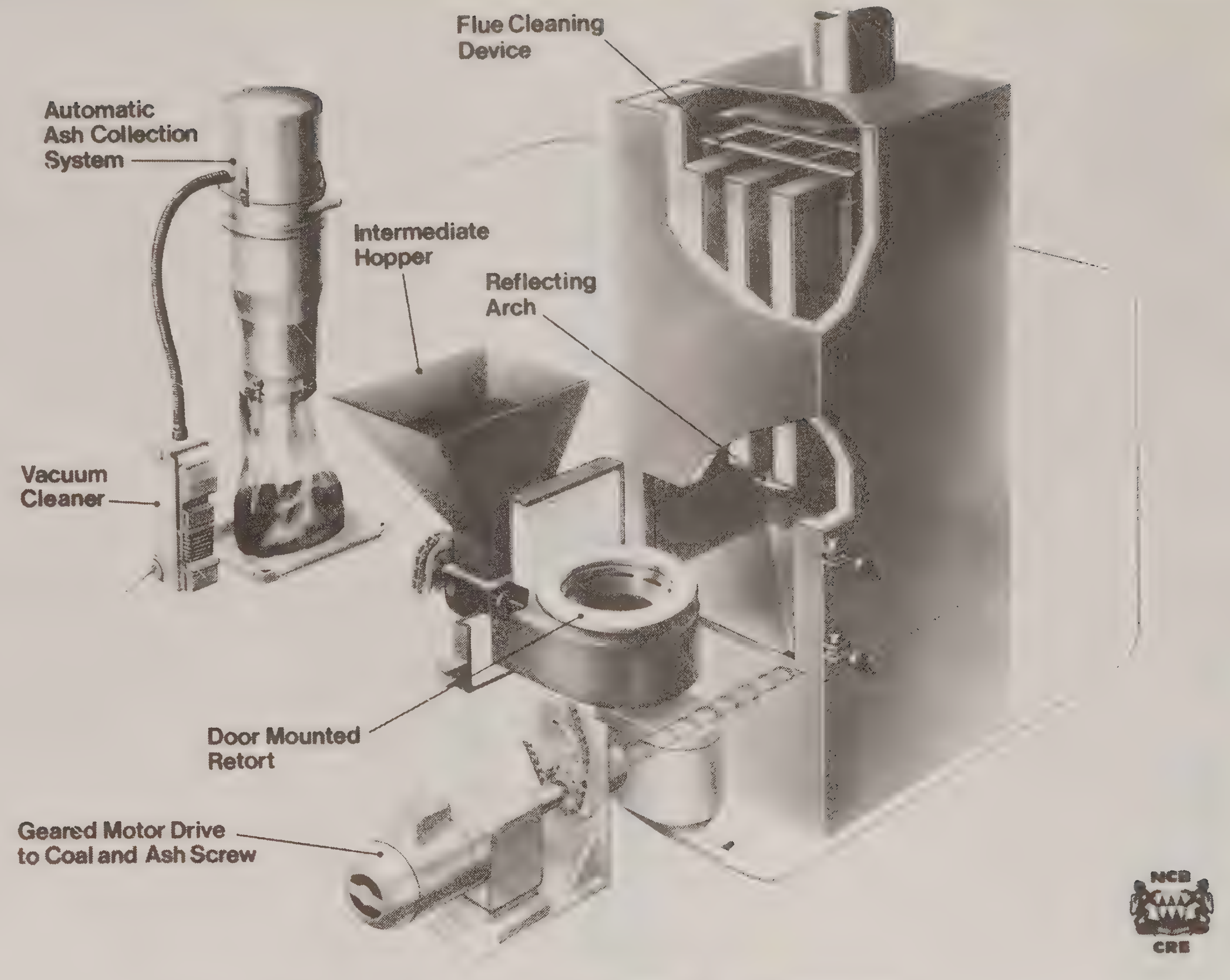

Filter Bag
To Vacuum
Ash Inlet (from appliance)
Automatic Cone Valve
Plastic Ash Container Bag
AUTOMATIC ASH DISPOSAL SYSTEM

FIGURE 8

Patent applied for



150kW FULLY AUTOMATIC COMMERCIAL UNDERFEED STOKER UNIT

FIGURE 9

Patent applied for

nsca

52nd ANNUAL CONFERENCE
14 – 17 OCTOBER 1985
SCARBOROUGH

– AIR POLLUTION CONTROL – SITUATIONS REPORTS – THE INCINERATION OF HAZARDOUS WASTES

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INTRODUCTION

The potential risks to the general public and to the environment presented by the landfilling of certain types of hazardous or toxic wastes have been emphasised upon a number of occasions over the years by particular instances of bad waste management. Such events have generated the demand for more sophisticated disposal options to be selected for such wastes and for tighter controls to be exercised over waste disposal activities generally. The incineration of combustible hazardous waste is one such option which has been developed in response to this demand and it now constitutes an essential and vital element of the United Kingdom's industrial waste disposal strategy.

CURRENT STATUS OF THE INCINERATION OPTION

The provision of hazardous wastes incinerators, in contrast to domestic refuse incinerators, has traditionally fallen to the private sector either as "IN-HOUSE" facilities operated by the waste producer exclusively for his own waste products or as "merchant" facilities operated by a small number (now totalling only 3) of specialist contractors on an ad hoc service contract basis. It is interesting to note that all other European countries which provide hazardous waste incineration facilities involve some measure of public funding.

The demand for incineration facilities is judged to represent some 1.3% of the 4.4M tonnes of hazardous wastes arising in England and Wales in 1984(1). This marks a significant decline from the 2% level recorded in the Gregson report(2) referring to the situation prevailing in 1981. Current merchant facility capacity is estimated to be 61,000 tonnes which is disturbingly close to the demand level of approximately 56,000 tonnes. Because of the poor commercial viability experienced by the merchant facility operators and uncertainties associated with future market demands the number of such facilities available has dwindled from eleven plants operating in 1974 to only four plants in 1985. The future market demand is a very complex issue to assess particularly at this point in time when industry is labouring under a depressed market economy and accordingly seeking by all means to reduce manufacturing costs to maintain a competitive business. Government in recognising these constraints on industry is reluctant to force them to achieve higher standards of performance especially where significant cost increases would result. Against this background incinerator plant operators are faced with the need to invest further substantial capital sums in ageing plants to up-date them in relation to the technological advances which have been achieved over the past decade especially in the field of gas cleaning about which this particular section of the conference is concerned. The commercial rewards from incineration to date do nothing to encourage this further investment and the industry is faced with a considerable dilemma.

INCINERATION COSTS

Incineration is an expensive disposal option with charges averaging in 1985 somewhere in the region of £250/te and extending to as high as £1200/te compared with an average for landfill charges of approximately £10/te.

The reasons for such high charges are many and varied embracing such aspects as capital investment, operating costs, laboratory charges, chemical composition, combustion gas cleaning requirements, residue ash disposal costs etc.

Two particular areas of cost are worthy of note and these are plant maintenance and support fuel which can constitute as much as 20% and 15% of the total annual operating costs respectively.

In the case of particularly toxic materials additional costs are incurred because of the need for more stringent controls to be exercised over handling and processing. Thus additional protective clothing may be required and the wearing of breathing apparatus may be prescribed.

Invariably in such cases closer monitoring of the workplace, stack emissions and operating personnel is demanded. To support such monitoring sophisticated analytical instrumentation is required and this may also involve the employment of external analytical agencies.

PRACTICAL ASPECTS OF CONTRACT INCINERATION

A major factor for consideration in design of a contracting incinerator is the infinite variability in waste arisings which the plant has to accommodate compared to an inhouse plant which is more usually fitted to a regular and established pattern of waste inputs. This infinite variability embraces physical consistency, chemical composition and calorific value.

The essential features of a hazardous waste incinerator comprise waste feed systems, the combustion furnace, gas cleaning and combustion gas discharge.

The waste feed systems provided must have regard for the variation in physical consistency and will range from conventional centrifugal pumps for mobile liquids through positive displacement ram pumps for sludges to shredding equipment for the truly solid waste arisings. Since much of the latter arrives at the incineration plant well and truly encased within a conventional steel drum, facilities for direct introduction of the drums have had to be developed. Robust shredding equipment capable of disintegrating such containers and contents prior to introduction into the furnace have only been developed in recent years.

The pumping systems need to be automatically linked to essential operating parameter monitors in order to sustain controlled combustion conditions on the one hand and to provide for immediate cut off in the event of plant malfunction on the other.

A variety of combustion furnace designs are available including fixed hearths with variations such as single cell, multi cell, cyclonic entry etc.; rotary hearth; vibrating hearth and fluidised bed.

The UK seems to have favoured the static hearth designs for one reason or another whereas the European operators more usually adopt the rotary hearth approach. Whatever the furnace design, certain fundamental requirements need to be satisfied. These relate to the three T's of efficient combustion, i.e. Temperature, Time and Turbulence, the latter to provide free access of air to the combusting material. In the case of hazardous waste incinerators catering for the combustion of thermally stable highly chlorinated materials such as PCB it is essential to sustain temperatures in excess of 1000 ^{o}C, provide combustion residence times in the gas phase for at least 2 seconds and allow sufficient combustion air access to provide a minimum of 3% excess oxygen.

The type of refractory material used in the construction of the furnace will have to be compatible with the range of operating temperatures anticipated, the chemical nature of the wastes catered for and the resultant combustion products. The furnace will be sized according to the designed total heat release and gas residence time required. All hazardous waste incinerators should be equipped with an afterburner zone within which additional support fuel burners and combustion air can be deployed to provide a safety back-up feature in the event of loss of temperature for whatever reason in the preceding combustion zones and to ensure complete combustion of all gaseous products prior to their release to atmosphere.

Efficient gas cleaning plant is an essential feature of a contract hazardous waste incinerator since the products of combustion will inevitably contain acidic components such as hydrochloric and sulphuric acids on a regular basis with hydrofluoric, phosphoric and nitric acids to a much lesser extent. A wide range of heavy metal oxides are also likely to be present and all these components have to be reduced to acceptable levels by "scrubbing" the gases with water prior to their discharge. A number of scrubber designs are available, ranging from the low pressure drop simple spray chamber, packed trickling tower and irrigated electrostatic precipitator to the high energy venturi system. The more efficient plants sometimes incorporate a combination of systems. In some plants the gases are scrubbed with an alkaline liquor which automatically is dosed with caustic soda to maintain a preset pH. Other plants wash with water and arrange for neutralisation of the acidic wash water after scrubbing.

Paradoxically it is generally considered that it is the resultant clean but dense water laden plume discharged from the gas cleaning plant which creates much of the local community aggravation and anxiety in respect of most incineration plants. In most respects an unscrubbed emission would be much less obtrusive and would disperse more readily into the atmosphere but would of course present a much greater risk of local environmental pollution. A further objective of washing the gas stream is to reduce the gas temperature from the 1000 °C+ down to a level of at least 300 °C for older plants and usually down to the region of 65 °C for more modern plants where stable gas volumes are required and in which plastic linings and structures are employed and which are incompatible with temperatures much above 80 °C. Considerable evaporation of the wash water occurs as is demonstrated by the fact that typically in the Re-Chem Pontypool plant generating a heat release of approximately 60M BTU's/hr the scrubber operates at a feed rate of 8500 gph of which some 2500 gph is evaporated into the exit gas streams.

With all the Re-Chem incineration plants the major part (70%-90%) of the solid particulate contained in the stack emissions is in fact neutral salts being predominantly sodium chloride, and to a lesser extent sodium sulphate, which is considered to derive largely from the evaporation of the scrubber liquor through the plant after the initial neutralisation of the acidic gas components. It is the presence of this salt particulate, often submicron in size, which is considered to be responsible for the stability of the vapour plume and to impart the residual haze which is a common feature of these emissions. The submicron size range of the particles presents considerable difficulty in its removal by normal wet scrubbing techniques.

REGULATORY CONTROL

Hazardous waste incineration and associated activities are governed and controlled under no less than eleven independent regulatory powers. The two principal legislative controls are exercised through the site licensing arrangements associated with Part 1 of the Control of Pollution Act 1974 (COPA) and the Registration of Chemical Incineration Works by HM Industrial Air Pollution Inspectorate, under the Health & Safety (Emissions into the Atmosphere) Regulations 1983 which is an extension of the controls provided by Part IV of COPA which in itself superseded the original legislation embodied in the Alkali Act of 1906.

Under site licensing arrangements a whole range of licence conditions can be imposed to regulate and control particular aspects of incineration site activities such as specifying types and quantities of materials permitted to be stored, segregation and methods of storage, provision of safety and emergency equipment, controls of spillages and site security and so on. The licensing authority is provided with a general appreciation of the operational regime with the licence application.

The registration by HMIAPI, which is administered within the HSE, is an annual requirement and this authority is specifically responsible for controlling the actual incineration activity. Control is exercised through the principle of best practicable means [3] (BPM) within the context of which presumptive standards for certain criteria are established. These include such matters as chimney stack height, gas efflux velocities, discharge limits for sulphur, hydrochloric acid, hydrofluoric acid and particulate solids etc. The concept of BPM takes account of both technical and commercial constraints upon incineration activities. In recent times the sphere of influence of the Inspectorate has been expanded to embrace such peripheral matters as adequacy of maintenance and technical proficiency, housekeeping and any matters affecting the impact of operations upon the local community and the environment.

Surveillance by both Principal regulatory authorities entails regular visits to plant by respective officers for inspection of appropriate permanent records, the procurement of spot waste samples and the independent testing of emissions.

Additional secondary regulatory controls are exercised through the following authorities:-

1. Waste Disposal Authority - Pre notification and recording delivery of (special wastes) to site under COPA (Special) Wastes Regulations of 1981.
2. Waste Disposal Authority - Disposal of incinerator ash at licensed landfill site. This activity is also regulated under COPA (Special) Wastes Regulations.
3. Regional Water Authority - Disposal of gas wash effluent to sewer/water course under licence to the appropriate regional water authority. Regular independent monitoring of effluent composition maintained and appropriate financial charges levied.
4. Health & Safety Executive - Working conditions of employees are vetted regularly by regional Factory Inspectorate administered through HSE. Concerned with any physical impact of operations on neighbouring factories or commercial establishments.
5. Local Environmental Health Authority - Concerned with any physical impact of operations upon the immediate local community and investigation of complaints therefrom.
6. Regional Fire Authority - Concerned with the storage on site of materials constituting a fire

hazard or which present a toxicity hazard to fire fighting personnel and others in attendance when subjected to an uncontrolled fire situation. Regular familiarisation visits are arranged and up-to-date schedules of stored chemicals are maintained at site.

7. Employment Medical Advisory Service – Consulted by various regulatory authorities in compiling safe systems of work or on the interpretation of specific monitoring data relating to operating personnel and the working environment.

8. Local Authority – The storage of Petroleum products with low flash points is licensed by the Petroleum Officer administered through the Local Authority according to the Petroleum (Consolidation) Act 1928. The officer satisfies himself in respect of the safety of storage, class of electrical installation and fire fighting provisions prior to issue of licence for such installations. The Company is given guidance on all such aspects during the design stage.

9. Radiochemical Inspectorate – Responsible for the issuing of licence to regulate quantity and type of low level radioactive waste which can be incinerated at the facility according to the Radioactive Substances Act 1960. Administration is through the Department of the Environment in England and the Welsh Office in Wales.

MONITORING OF OPERATIONS

There are a number of distinct aspects to be considered in relation to the monitoring of hazardous waste incineration activities which can conveniently be divided into the following categories:–

i) On site monitoring of plant performance.
ii) On site monitoring of environmental impact of operations.
iii) Off site monitoring of environmental impact of operations.

Each aspect is discussed separately in the following text.

i) Plant Monitoring - Whenever possible essential operating criteria should be automatically recorded so that such data can be referred to subsequently by plant management and Regulatory Officers when investigating specific complaints or plant events. Such data for which reliable continuous monitoring instrumentation is now available includes Cell Temperatures, Furnace pressure, smoke density and oxygen level. The greatest difficulty lies in the correct siting of the respective monitoring probes to obtain meaningful and accurate data.

Certain data can only be obtained by manual sampling followed by laboratory analysis of the extracted component. Chemical analysis of waste feedstocks and stack emissions are the main criteria in this category. Attempts to develop continuous monitoring instrumentation to measure organic residues in stack emissions are continuing through a research project being undertaken by the Harwell Laboratories and jointly financed by the Department of the Environment and the merchant incinerator operators.

Re-Chem has been successful in computerising the continuous monitoring of its Pontypool plant such that a number of control functions including burner feed rates and stack damper are automatically and continuously adjusted from the monitoring data which is sensed and fed into the computer at a rate of some 20 times per second. Very impressive plant control is demonstrated by this system.

Typical stack monitoring data associated with the Pontypool Plant is provided in Table 1 and relates to emissions monitored regularly over the twelve month period of 1984. (Data presented graphically in Fig 1.)

ii) On site monitoring of environmental impact of operations. There is no continuous automatic monitoring instrumentation available which can be employed to detect the environmental impact of incineration operations on site and again we are therefore dependent upon manually arranged sampling of the workplace environment for subsequent chemical analysis of absorbed species. There are available specific test systems for certain chemical compounds which rely upon colour reactions to quantitatively identify the presence in air of the chemical in question. The Draeger tube system is an example but in most cases the level of detection is too high to be of much use in this particular application although they do usually serve to indicate whether or not the actual level is below the toxicity threshold level.

A further opportunity to assess the impact of operations on site is provided by the medical surveillance of the workforce. Regular and systematic medical examinations should be a feature of all such operations and the normal medical screening programme should be augmented by specific tests to reflect any particular toxicity to which the employees may be potentially at risk. Thus for example the Re-Chem employee medicals have included tests for lead, cyanide and latterly PCB being specific components of wastes regularly processed through the plant.

iii) Off site monitoring of environmental impact.
Although the concept of environmental impact assessment as a pre requisite for planning approval of new industrial activity has been developed over several years now, the provision of regular external monitoring of existing operations is a fairly new departure especially for the waste disposal industry. The programme initiated by Re-Chem International in mid 1984 covering all three of its original operational areas – viz. Fawley near Southampton, Pontypool South Wales, and Bonnybridge near Falkirk Scotland – was in direct response to the growing anxiety of the local communities at all three locations concerning potential risks to health from the incineration activity. This anxiety has been engendered by sustained media attention over a prolonged period of almost two years during

which time attempts have been made by various organisations to relate wide ranging circumstantial evidence of animal sickness, cancer and congenital malformation in infants to emissions from incineration plant. In spite of intense investigation of these matters by many independent authorities no scientific evidence has ever been discovered to support the alleged connections whereas to the contrary much analytical data has been produced both by the Company and by independent authoritative analytical establishments to demonstrate the efficiency of the incineration activity on the one hand and the absence of any significant environmental impact on the other.

The Re-Chem environmental monitoring programme involves the monthly sampling of soil and foliage at thirteen or so locations distributed around each incineration plant locality. Sampling is carried out in accordance with established protocol(4 & 5). The selection of sites had regard to annual wind patterns, areas of particular community anxiety, potential for disturbance of ground or treatment with chemicals etc.

Each site is monitored for PCB, antimony, arsenic, cadmium, copper, lead, mercury, molybdenum, selenium and zinc. These materials were selected partly in the knowledge that they were regular constituents of waste incinerated and partly from the agricultural significance of certain elements. Analytical quality control features were built into the programme and split sampling is arranged with independent analytical establishments in order to establish the validity of the data produced. A consolidated presentation of results obtained from this programme for the period of July 1984 to January 1985 inclusive is shown in Table 2. It is reassuring to observe that the data shows no statistical correlation in relation to either prevailing wind direction or distance from incineration plant, which would have been the case had there been any significant impact of emissions upon the local environment. No site except one in the Fawley area, for which special circumstances unconnected with

Re-Chem operations exist, exhibits exceptional levels of the components determined.

CONCLUSIONS

The incineration of hazardous wastes under appropriately stringent conditions of temperatures in excess of 1000 °C and furnace residence times in excess of 2 seconds has been demonstrated to be safe and effective even for the most thermally stable organic substances and it remains the best practicable environmental option (BPEO) for the disposal of many classes of this type of waste. The concern and anxiety displayed by communities residing close to such plants is perfectly natural and understandable and it is beholden on plant management to do everything possible to reassure them on all aspects of the operations in order to reduce such anxiety to the basic minimum. However, it is unfortunate that ill-informed comment and mischievous misrepresentation of the facts has so often been the means to exploit both communities and plant operators for political gain, personal glorification and media sensationalism. It is to be hoped that the efforts now being made to provide more scientific data on the true state of the environment surrounding incineration plant will make for a better understanding of the matter and more ready acceptance of the vital need for such facilities to provide industry with a full range of disposal options. The capital investment demands to sustain these plants in a state of ever improving operational standard is presenting shareholders with a considerable dilemma, given the current period of industrial recession and future market uncertainty, and there is some doubt as to whether this industry can remain commercially viable in its present form.

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4. "Sampling of farm crops, feeding stuffs, milks and water for analysis". HMSO London 1977.
5. Draft British Standard Code of Practice for the identification and investigation of contaminated land. Document 83/55992, BSI, 1983.

TABLE 1 RE-CHEM INTERNATIONAL LIMITED
INCINERATOR STACK EMISSION DATA
LOCATION PONTYPOOL PLANT

Species	Compound	YEAR (1984)		
		Number of Tests	Mean Value	Range of Values
ORGANICS	PCB	17	0.11	0.005-0.41
PARTICULATES	Total Solids	36	267	146-471
	Cadmium		0.002	0.0005-0.01
	Chromium		0.6	0.03-2.3
	Copper		0.5	0.02-2.3
	Lead		1.1	0.1-4.8
	Nickel		0.5	0.02-2.5
	Zinc		2.3	0.4-5.8
"ACIDITY"	Total Chlorides	206	220	25-500

UNITS:- PCB ug M^{-3}
REMAINDER Mg M^{-3}

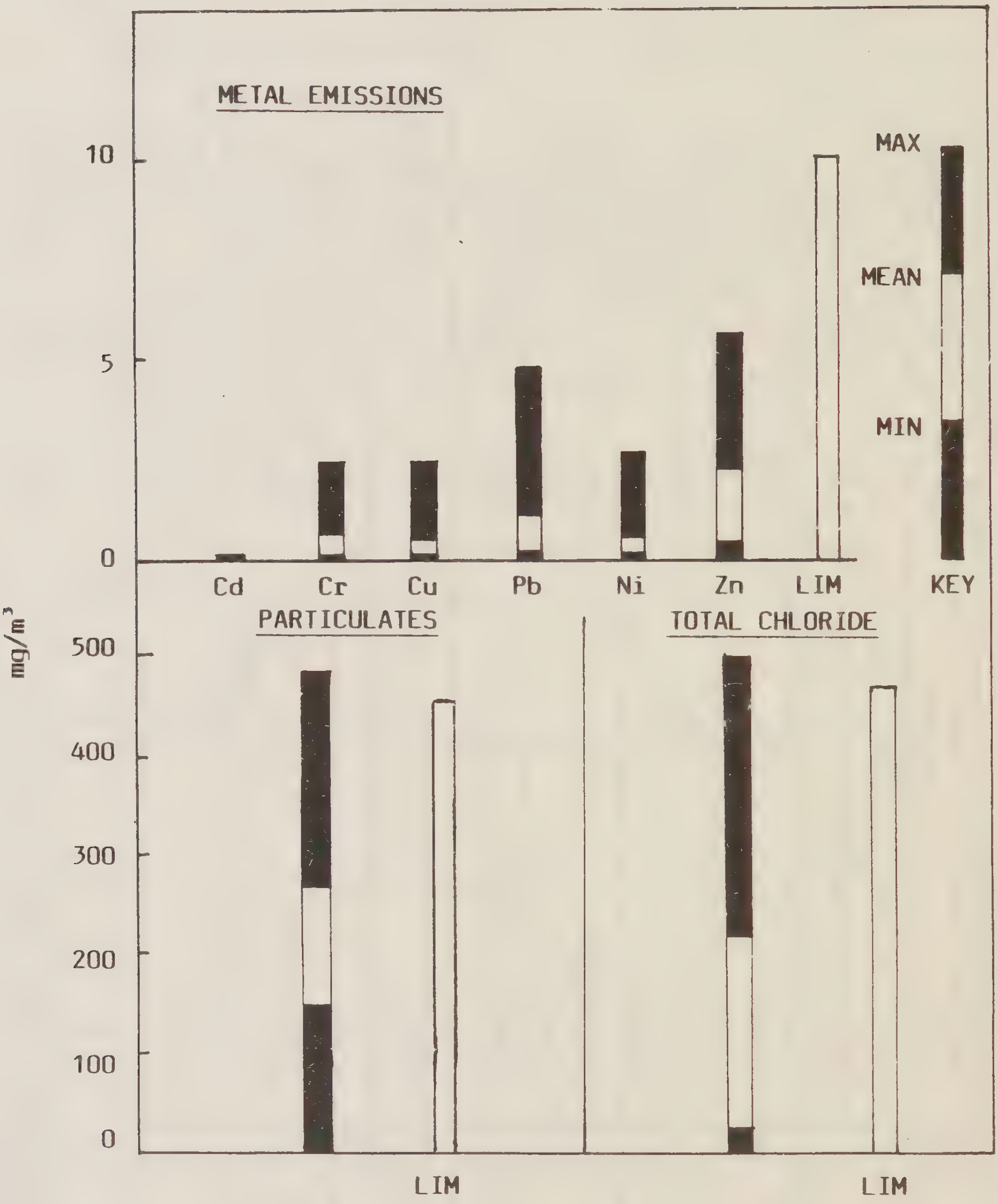
TABLE 2 RE-CHEM INTERNATIONAL LIMITED ENVIRONMENTAL MONITORING DATA PERIOD JULY '84 - JAN '85

		SOIL				FOLIAGE			
		FAWLEY	PONTYPOOL	ROUGHMUTE	"NORM" BACKGROUND	FAWLEY	PONTYPOOL	ROUGHMUTE	"NORM" BACKGROUND
PCB	High	253	26	48	1000	58	18	65	320
	Low	1	5	5	10	3	5	3	15
	Mean	19	10	13	40	13	9	15	
COPPER	High	29	51	39	300	16	63	16	15
	Low	0.2	0.1	0.5	2	0.1	0.1	0.1	4
	Mean	6	7	10		5	4	4	
CADMIUM	High	2	3	9	30	2	3	3	5
	Low	0.1	0.1	0.1	0.01	0.1	0.1	0.1	2
	Mean	0.6	0.8	1		0.5	0.7	0.6	
LEAD	High	82	195	173	200	55	95	79	10
	Low	12	1	11	2	2	0.1	2	0.1
	Mean	38	58	64		12	12	19	
ZINC	High	342	245	405	300	296	177	247	200
	Low	26	29	63	10	36	21	52	15
	Mean	94	109	140		108	79	95	
MERCURY	High	0.1	0.3	0.1	0.3	0.1	0.1	0.1	0.3
	Low	0.1	0.1	0.1	0.01	0.1	0.1	0.1	
	Mean	0.1	0.1	0.1		0.1	0.1	0.1	
ANTIMONY	High	2	21	13	10	0.9	8	11	0.1
	Low	0.1	0.1	0.1	0.2	0.1	0.1	0.1	
	Mean	0.4	4	2		0.2	1	2	
ARSENIC	High	18	28	21	40	2	21	4	5
	Low	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Mean	7	11	6		0.4	1.4	0.6	
SELENIUM	High	2	0.1	92	10	0.1	0.1	6	2
	Low	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2
	Mean	0.3	0.1	4	10	0.1	0.1	0.9	0.02
MOLYBDENUM	High	0.1	0.1	16		0.1	0.1	25	
	Low	0.1	0.1	0.1		0.1	0.1	0.1	
	Mean	0.1	0.1	1		0.1	0.1	3	1

UNITS:- PCB ug kg^{-1}
METALS mg kg^{-1}

FIGURE 1

RE-CHEM INTERNATIONAL LIMITED
INCINERATOR STACK EMISSION DATA
LOCATION PONTYPOOL PLANT



Cd = Cadmium

Cr = Chromium

Cu = Copper

Pb = Lead

Ni = Nickel

Zn = Zinc

LIM = Presumptive Limit

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52nd ANNUAL CONFERENCE
14 – 17 OCTOBER 1985
SCARBOROUGH

– NOISE –
NOISE AND HEALTH
A BRIEF REVIEW OF RECENT RESEARCH

– By –

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AMENDMENTS

Noise and Health - A Brief Review of Recent Research

By F.J. Langdon

Page 8, last two lines of last paragraph should read:

$p<0.001$) and that the former was closely related to
noise level (r(individual) = 0.24: $p<0.001$).

Page 9, first paragraph, twenty-second line should read:

significant correlation ($r=0.88$, $n=26$: $p<0.001$) and

Given the wide connotation of the terms 'noise' and 'health', the complexity of the ways the former may impinge on the latter, and the time and space available to discuss these issues, what follows can only be a brief, inadequate and inconclusive review of a very controversial topic. Apart from the problems of industrial noise, constituting a whole sub-region of highly specialised studies, and one in which I can claim no expertise, the area covered by environmental noise may be divided into four main categories. These are to some degree arbitrary and overlapping, but they are at least one practical, useful way of trying to impose some sort of order on chaos. I will therefore consider in turn:

1. impairment of hearing and some of its consequences
2. effects of noise on mental health
3. effects of noise on general physical health
4. effects of noise on sleep.

It should be evident that in considering the subtle and multifarious ways noise can adversely affect the community, the only sensible definition of health is 'the maintenance of a state of physical, mental and social well-being'. The adoption of precise, clinical health criteria is often inappropriate in this field, and moreover the data at present available can rarely meet these requirements. Nor can cause and effect be proved but in most cases can merely be inferred or even speculated upon. Having made all the necessary excuses, apologies and 'cop-outs', let us begin by looking at hearing impairment, probably the best documented and least disputed case against noise.

1. HEARING IMPAIRMENT

We all know that noise can damage our hearing. The ancient Egyptians living near the Nile cataracts knew this and the ancient Greek travellers, Thales and Herodotus, incorporated their 'shock, horror' stories in their own accounts. But to pass on from this and specify how much noise causes how much damage is not so easy. A leading world authority (Dixon Ward 1984, 1985) comments on this, that we know more than the ancients, and more than Francis Bacon, but is unsure how much more we know. For almost everyone, hearing gets worse as we grow old. But how and why this happens is not altogether clear. Until fairly recently the story went something like this: assuming that we start with 'normal' hearing, the ageing process brings about progressive reduction in the number of live hair-cells in the cochlea, a process called presbyacusis. In the case of hearing damage, excessive doses of noise cause premature damage to and death of hair-cells. This is termed nosoacusis. Of course, this is a grossly over-simplified picture which leaves out other forms of damage such as tinnitus (singing and whistling in the ears) or paracusis (hearing sounds incorrectly) and many other conditions.

But the main difficulty with this account of things is that it has been hard to test and substantiate. Let us begin at the beginning. What is 'normal' hearing? Is it the hearing of a group of healthy young people? And how do we measure it to obtain this 'normal' average? If we apply standard clinical otology, 'normal' hearing turns out to mean the ability to hear pure tones at certain sound pressure levels over the range of frequencies. But this is not what we are normally listening to. Research has shown that perceptual thresholds for pure tones do not correlate very highly with ability to hear sounds such as clicks or phonemes, or to identify words and phrases correctly (Ward, 1984, 1985). And our test group of healthy young people will inevitably have already suffered some degree of nosoacusis. For instance, present studies suggest that US schoolchildren have already been exposed to a noise dose of around 80 to 85 Leq daily (Siervogel et al 1982).

The account of the ageing process also has its problems. Studies of hair-cell damage have not shown good correlation with threshold hearing levels (Liberman & Kiang 1978). Hair-cell losses may be accompanied by near normal thresholds (Henderson et al 1974), while low-frequency hearing losses can exist despite a normal complement of healthy cells (Hunter-Duvar & Elliott 1973), and similar studies have demonstrated hair-cell deficits even in new-born controls (Coleman 1976). In general, evidence seems to be accumulating that the ageing process is to some degree physiological and in part the result of continued noise exposure (sociacusis). Not that this suggested model is without its difficulties. Reporting to the 1983 Torino Congress on Noise as a Public Health Problem, Dixon Ward (1985) cited thirteen cross-sectional studies of workers exposed to occupational noise, from musicians and mine locksmiths to firemen and ambulance drivers, who failed to show significant differences from controls. He went on to point out also that longitudinal studies of hearing decline have likewise "produced some rather strange results".

Despite the failure of studies based on individuals to show a close correspondence between temporary threshold shift (tts) and permanent threshold shift (pts), or impaired hearing and cochlear damage, group studies nevertheless support the general thesis of progressive cilial damage through excessive and repeated noise dosage. The main problem in trying to measure hearing damage from noise exposure is simply that the exposure history, both for nosoacusis and for sociacusis, of the people being tested is usually not known and can be only roughly estimated. At present we must therefore make the best practical use of standardised test procedures and apply industrial hearing conservation programmes without the benefit of fully satisfactory supporting theory.

What has perhaps been underestimated in the past is the contribution of sociacusis. More attention is now being paid to things such as the effects of gunfire on whole age-range sections of the population (Ward et al 1961), and the effects of chain-saws, electronic equipment, etc. This last has prompted numerous studies of the effects of disco and live pop music, both on musicians and on listeners.

The most extensive of many studies, comprehensively reviewed by Whittle and Robinson (1974), is probably that by Fearn (1972, 1973a, 1973b) who concluded that the risk of permanent damage is small for the great majority of disco attenders, despite periods of exposure to maximum levels exceeding 110 dBA. The chief reason for this is that actual duration and frequency of exposure is insufficient to provoke permanent damage. A greater risk is incurred by a smaller percentage of 'aficionados' and pop musicians with a possible loss of 1 dB upper frequency threshold per year, a just detectable loss over a five year period.

Such effects are not confined however to pop musicians. A study of classical orchestral musicians (Rabinowitz et al 1982) concluded that over the period of a professional career, some 30% of players, mainly from brass and percussion sections, showed losses of up to 20 dB, together with tinnitus, headache and feelings of malaise after performances. On the other hand, a study of military brass band musicians (Petrovic et al 1979) failed to detect significant hearing losses, so it would seem that even this limited area of study is not free from controversy. Again, variable outcomes seem to arise from the use of 'personal' headphones, such as Sony Walkmans. A recent report on current research not yet completed (Fox 1985) suggests that danger can arise from persistent use of such equipment, especially playing pop music, which has little dynamic variation, at high levels, though moderate and reasonable use of headphones is unlikely to affect hearing permanently. But widespread use of personal headphones is such a comparatively recent phenomenon that it is doubtful whether the evidence from which to draw firm conclusions has yet been generated. Enough youngsters will have had to make themselves deaf before we are able to be sure about any harmful effects.

There is one further group of adverse effect which calls for brief mention, and this is the pathological and social consequences of noise-induced deafness. A person suffering from a severe deficit tends to withdraw from conversation and progressively from all types of social interaction. This can lead to pathological states of paranoia, hallucinatory and delusional experiences (Mahapatra, 1974: Singerman et al, 1980). The association between psychiatric morbidity and hearing loss has also been confirmed in another way by statistical surveys of mental hospital patients (Jeter, 1976, McCoy and Plotkin, 1967) which have shown percentages of deaf patients to be over four times the figure for the population at large. It is not difficult to see that a disability such as misperception of speech - a common result of hearing loss through inability to hear upper frequencies, mainly occupied by consonantal sounds - is likely to foster delusional experiences leading to paranoia, leading in turn further and further into social withdrawal. And if exposure to noise is responsible for loss of hearing then it would seem some mental disorder is caused by noise.

2. EFFECTS OF NOISE ON MENTAL HEALTH

While what has just been described is a possible indirect effect, it has been claimed that psychiatric disorder can result directly from exposure to excessive noise. Early studies of admission rates to mental hospitals in the vicinity of an airport appeared to suggest a definite positive relationship, particularly in the case of elderly women (Abey Wickrama et al, 1969). However, a later, larger scale study (Gattoni and Tarnopolsky 1973) failed to confirm these findings and the general weight of evidence has tended to suggest that noise does not operate in any simple and direct fashion. It would be more correct to say that noise does not directly provoke mental illness, but can affect psychiatric patients adversely. They react negatively to noise more than other people; it depresses them and makes their condition worse. What noise does with regard to mental health is basically to annoy people, especially those known to be particularly sensitive to noise, and undermine their psychological equilibrium (Tarnopolsky and Morton Williams, 1980). In any case, as has been shown by another large scale study of London mental hospitals

(Jenkins et al 1979), the effects of noise cannot be completely separated from those deriving from other social, demographic and economic factors. Nevertheless, despite the difficult and controversial nature of the material involved in all such studies, both the last two surveys referred to allow for the possibility of noise as a causative factor, even though not a major one, for at least the more vulnerable sections of the population.

3. EFFECTS OF NOISE ON PHYSICAL HEALTH

Does noise have any measurable direct effect on people's physical health? Three areas in which such effects could show have been studied; cardiovascular and hypertensive states, teratism, and general physical well-being.

The main evidence for the first mentioned comes from studies of hypertension in the neighbourhood of Schiphol (Amsterdam) airport (Knipschild, 1977), and also from a survey of American schoolchildren (Cohen et al, 1980). Knipschild found that cardiac hypertension occurred among 10% of the population in quiet areas, as against 15% in noisy areas (significant at 1% level) and that the use of cardiovascular drugs was also related significantly to noise levels. A parallel general health survey also revealed that in the noisier areas closer to flight paths, inhabitants "had more need to seek the help of their family doctor" (Knipschild, 1980). A third and final study also showed a significant growth in the purchase of antihypertensive drugs in an area not previously exposed to aircraft noise in the course of the six years following the opening of a new runway, purchases roughly doubling over this period. Knipschild's findings appeared to be confirmed by a later analogous survey dealing with exposure to road traffic noise (Neus et al, 1985). Nonetheless, it must be noted that as against these reported findings and others of a similar character in USA, a wide ranging review of all the relevant literature (Thompson, 1985) claims that there is no definite evidence to prove that noise is responsible for cardiovascular disease or hypertension.

Francois (1975, 1980) looked at the effects of noise on health in a broader way by comparing numbers of visits to doctors, consumption of drugs, and respondent self-ratings of health state for a sample of the populations around Orly and Charles de Gaulle airports, with a matched sample of the whole French population. This study is interesting for two reasons. First, the Charles de Gaulle airport sample was visited twice, once before the new airport opened and again after a year's operation. Second, the self-report of health state could hardly avoid introducing mental along with physical symptoms. Francois concluded that there was no discernible difference between the general health of residents around Charles de Gaulle airport and that of the sample French population, whether they lived in planning zones A, B or C (nearest to or furthest from the airport). In the case of Orly however, where over half the population have been exposed to aircraft noise for more than ten years, a marginal difference was detected. This was not so much in formal terms of definite 'illnesses', but rather in feelings of fatigue, malaise and general loss of well-being. Hence it would seem the effects of noise on health were not very well marked, and where a planned modern airport, operating with quieted 'second-generation' aircraft, restricted residential development to well defined zones there appeared to be no adverse effect at all. It is worth noting that Orly airport residents must over the years have been exposed to much higher noise levels than residents of contemporary Charles de Gaulle.

There remains the work which has been carried out by Ando and Hattori (1973, 1977) in the vicinity of Osaka airport in Japan. They reported that babies of mothers living close to flight paths were of abnormally low birth weight. This has nothing to do with the actual birth circumstances but was deduced as being the consequences of stress experienced by mothers during pregnancy and due to noise. These findings were paralleled by those from a similar study carried out around Los Angeles airport (Jones and Tauscher, 1978), though it may be noted that their results have been criticised for failing to take into account physical pollutants (CO, unburnt fuel, metal particles, etc.) and socio-economic factors. The problem here is that the noise stressor operates within the context of related factors – such as economically worse off people living in noisier and more crowded areas. There is also the fact that, as was suggested by the work of Tarnopolsky, already mentioned, noise often has an indirect effect, operating through feelings of annoyance. This need not be related directly to physical noise level, as has been shown by the work of Bryan and Tempest (1973) and of Weinstein (1980) which has brought out clearly the existence of extremely vulnerable groups of people within the general population.

4. EFFECTS OF NOISE ON SLEEP

I have reserved the last part of this paper for what is perhaps the most widespread, and certainly the most intensively studied, effect of noise: namely, that on sleep.

There are many ways of looking at this topic, objectively and subjectively. However, contrary to what might have been expected on common-sense grounds, it is the objective studies which have produced the most uncertain results which require subjective interpretation, while subjective surveys have yielded a fairly clear and quantitative picture.

In a survey of residents close to John F Kennedy airport New York, Borsky (1976) assessed disturbance to sleep from noise, relying mainly on two indicators; difficulty of getting to sleep, and the difficulty of getting back to sleep after having been awakened. Borsky concluded that the quality and duration of sleep was directly related to the intensity of noise exposure. Some 60% of residents living a mile from the airport reported some form of sleep disturbance as compared with 30% of those living five miles, and 10% of those living ten miles away. It was also clear that annoyance and sleep disturbance were closely related ($r = 0.77$: p 0.001) and that the former was closely related to noise level ($r(\text{individual}) = 0.24$: p 0.001).

These results may be compared with those obtained by Langdon and Buller (1976) for disturbance to sleep caused by road traffic noise. In the study already referred to, Tarnopolsky (1980) found that report of health adversely affected by aircraft noise related to noise levels but only when the base for computing the correlation was a question asking the respondent specifically about noise. When noise was not mentioned no significant relation was found. In the case of the traffic noise survey, it had earlier been found similarly that where noise levels were high residents tended to attribute sleep disturbance to traffic noise more than where noise levels were lower. But since the proportion of residents reporting disturbed sleep from all causes remained the same irrespective of noise level - which necessarily implied that where noise levels were higher sleep disturbance from causes such as pain or anxiety was less - this information was regarded as suspect. A simple correlation between sleeping in a room facing the road, with windows open or shut in summer weather, and measured noise level yielded a highly significant correlation (r=0.88, n=26: p 0.001) and showed that at noise levels approaching 75 Leq only about 30% of residents could sleep undisturbed with windows open, and that even in the quietest conditions found in the survey with noise levels around 35-40 Leq there would still remain some 20% of residents disturbed by noise unless they closed windows. The survey also showed that relatively few people resorted to sleep-inducing drugs as a counter-strategy to noise. Use of drugs related far more to overcoming pain or anxiety. To overcome the effects of noise people relied on sleeping in rooms away from the road or on closing windows - even in warm weather.

Since closing windows reduces noise in the room by about 10 dB - at the cost of some thermal discomfort in warmer weather - and is the general response to excessive street noise levels, it might be supposed that acoustic double glazing would reduce sleep disturbance. This was in fact found to be the case in a recent study by the Building Research Station (Utley 1985) in which residents of dwellings so equipped expressed satisfaction, though with some reservations over noise generated by the ventilator fan and the general appearance of ventilators. It also became clear that the double glazing failed in its purpose where night noise levels were of the order of 75 Leq for in these conditions the overall reduction of about 10 dB afforded by the installation would be insufficient to guarantee acceptable internal levels.

In contrast to the results of the BRS study, a Dutch survey (Kumar et al 1985) measured sleep disturbance by means of physiological (EEG, EOG, ECG) and psychological (Mood Profile, Questionnaire of Sleep Quality, etc.) methods but found very little difference between the sleep of those with and those without double glazing. Although double glazing did reduce noise levels by at least 10 dB, it was concluded that this did not improve sleep quality because disturbance was caused mainly by noise peaks from individual noisy passing vehicles - particularly noticeable in reduced night traffic flows - and that these peaks remained despite double glazing. Of course, it may be that there is no real contradiction between these two studies, which for the highest noise levels are in agreement.

So much for disturbance to sleep as directly reported. But it may be asked whether such disturbance is itself evidence of a deterioration in the quality of sleep, and thereby an adverse effect on health.

Physiological studies of sleep and sleep deprivation have been carried on for a long time, largely independent of the problems of noise. A variety of measures including EEG, ECG, EOG, Heart rate, vaso-constriction, body movements, etc., have been employed. In particular, the study of the electroencephalogram (EEG), standardised by an agreed interpretative scaling procedure, has shown sleep to have a definite structure from the moment of falling asleep to the process of awakening. From the progressive stages of sleep, particularly those identified with 'deep' sleep (presence of 'delta' waves) and periods of dreaming, it seemed logical enough to conclude that the amount of time spent in 'deep' sleep could be used as a measure of sleep quality. A reduction of 'delta' sleep caused by exposure to noise would thus indicate a reduction in sleep quality.

A number of experiments over a long period with subjects sleeping under a variety of conditions, either in a laboratory or in their own homes, duly demonstrated this relationship. A general result of noise exposure was a shift from delta sleep to 'shallower' stages and usually less time spent dreaming indicated by cessation of rapid eye movements (REM). Nevertheless, the difficulty remained. How was it to be proved that these changes did in fact indicate a deterioration in sleep quality? A principal outcome of all this work has been, contrary to the earlier assumptions, to cast doubt on the value of sleep stage evaluation as a useful measure of disturbance (Ehrenstein and Weber 1980, Muzet 1985).

A different approach is that exemplified by the work of Wilkinson (1981) who developed an effective measure of sleep quality through simple performance tests carried out during the day following sleep under either experimental or control conditions. This method was recently employed, along with the physiological measures described above, in a large scale joint study carried out by four EEC member countries (Jurriens et al 1985). The conclusions of this detailed study of 70 healthy persons sleeping in their own homes under both quiet and noisy conditions varying between 40 and 52 Leq in the bedrooms for a total of about 1000 nights, suggest that sleep quality is definitely reduced in terms of impaired performance of test tasks on days following sleep in noisy conditions, as measured both in the morning and at times later in the day. Sleep quality was also reduced when measured subjectively by mood scales and subjects' self-rating. Subjects were also more wakeful during noisy nights; heart rate increased following peaks of noise and was generally more variable in the noisy condition. On the other hand, EEG measures did not appear to provide a very useful guide to sleep quality or its impairment.

It should be noted however, that despite these valuable findings in what is clearly a difficult area of research, and although one may say that the adverse effects of noise on health through both deprivation of sleep and impairment of its quality have been made clear, we have yet to quantify this. It seems that relatively little adaptation to noisy conditions occurs for sleepers and we do need to know more of what are permissible levels, and particularly peak levels, of noise if healthy sleep is to be assured - not forgetting the need to be able to keep windows open whenever we wish to!

5. A BRIEF SUMMARY

Beginning with the direct effects of noise, loss of hearing is clearly the most important and the most to be deplored. Although hearing damage as an industrial hazard is still unfortunately more widespread then it should be, many of the noisier industrial processes are on the decline and technologies are changing; noise protection technology is well understood, while hearing conservation programmes and regular auditory monitoring are now common. It is in fact as a result of applying such programmes over a number of years that doubt has been cast on a too close relationship in each individual case between noise exposure and hearing loss. At present the main danger to hearing comes increasingly from environmental noise for which there is no conservation programme. At the same time, study of exposure to live and recorded pop music has not revealed anything that can yet be described as a menacing phenomenon.

It seems to be difficult to make much of a case for noise as a direct threat to physical health. The main effect is an indirect one as an environmental stressor. And here the main effect would seem to lie in the regions of extreme annoyance caused by noise, not necessarily at the highest levels, but to those most sensitive to noise, and to those already suffering from, or on the brink of frank psychiatric disorder. Surveying this whole field one is continually struck by the gap between social experience embodied in respondents' answers and 'self-reports' in surveys, the experience of general practitioners with respect to their patients, and the difficulty of demonstrating beyond controversy the effects of noise on either physical or mental health.

Finally there is sleep. It is here, I think, that the adverse effect of noise has been most clearly shown. No doubt its effects are relatively slight. For levels of noise at which it is still possible to get to sleep and remain asleep it is doubtful whether such effects are seriously comparable with all the other types of physical health hazard and social environmental stressors. Nevertheless, it is important to quantify these effects, if only to protect those members of the community most vulnerable or most exposed.

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– NOISE –

AIRCRAFT NOISE CONTROL PROSPECTS FOR THE 21st CENTURY

– By –

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INTRODUCTION

A quarter of a century ago, the development of the commercial jet engine initiated a process of transformation in air travel. However, in providing an attractive fast and efficient form of transport, it also shattered the comparative quiet of life around airports and, despite becoming progressively quieter, has been the subject of environmental concern ever since. As a consequence we have seen the birth and exponential growth of an activity that has involved the public, politicians and legislators as well as all sections of the air transport industry. There is a belief that the success of this business has now laid the airport noise problem to rest and, at a time when many of the older, noisier aircraft are being outlawed around the world, it is timely to inspect whether this is true or not.

From the industry standpoint there is now the hope that the remainder of the century will see a decline in spending related to aircraft noise control, which currently runs at around $1 billion annually; whilst from the politician's viewpoint there is the hope that the measures now engraved in national legislation around the world will reverse the tide of complaints. Whether these hopes will be realised, as the world fleet reshapes itself to embrace modern technology across the wide spectrum of aircraft types, will be a function of the reaction of the airport neighbour to the evolving situation.

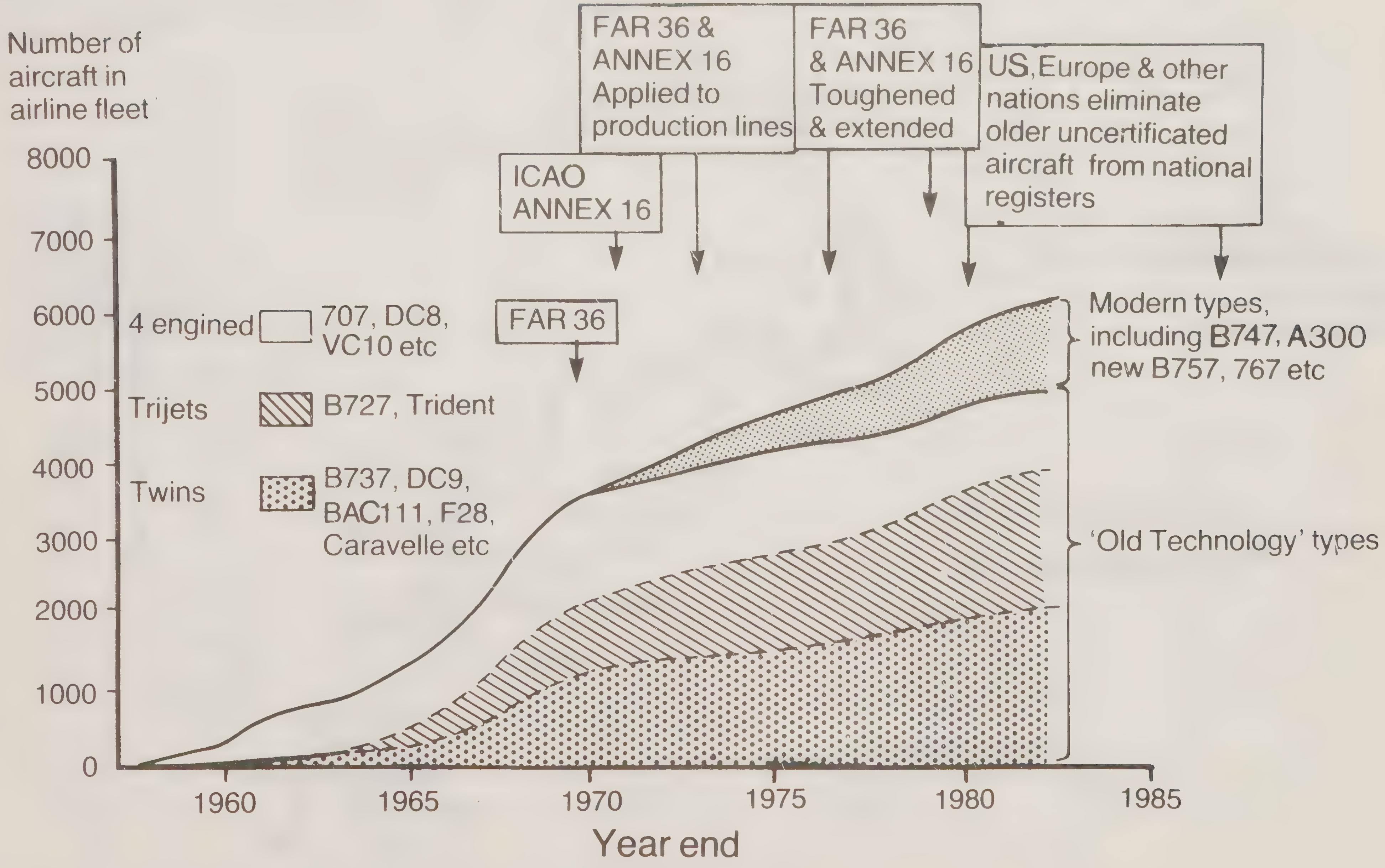
From a planning standpoint, those of us in the manufacturing industry need to examine whether the noise reductions that we have achieved in the last quarter century provide for an environment that will allow us to de-emphasise the issue and concentrate upon improving the efficiency of the modern aeroplane. If not, then we must accept that noise will continue to be a major design constraint and establish research and development programmes accordingly. The broad view of the future is therefore of critical importance, and must be constructed with an eye to past experience.

BACKGROUND

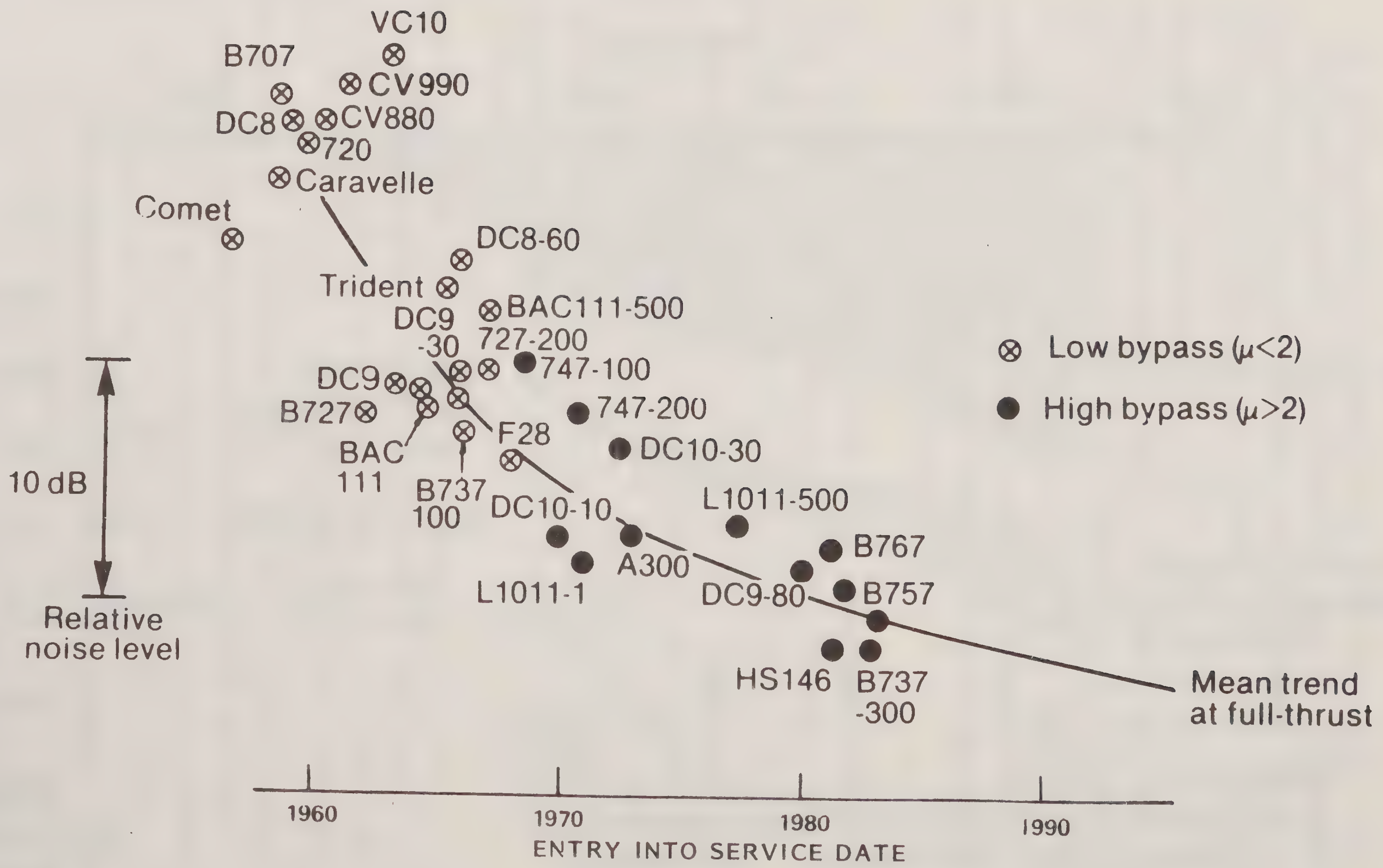
It is appropriate to examine firstly the origin and scale of the jet aircraft noise problem, for it gives some insight into the factors that influence the issue. Undoubtedly jet engines are noisy, less now than they were a quarter of a century ago, but viewed against other environmental sources there are still few that exceed them in absolute level. Whilst aircraft noise is a transient feature, rising and decaying as the aircraft approaches and then overflies the observer, the patterns of operations at major airports are such that the noise "events" are sequential and spread over many hours, and this repetitive feature influences public reaction as much as the absolute noise level.

This repetitive, or "frequency of intrusion" element, is given impetus as airports grow to accommodate an enlarging world fleet. Figure 1 indicates how the scheduled airline jet fleet has expanded in less than 30 years from nothing to the order of 7,000 units, most of which operate daily in and out of major and regional airports. Additionally, there is an almost equal number of privately operated jets in the business and general aviation sectors that not only add to the major airport problems, but create additional unrest at smaller airfields.

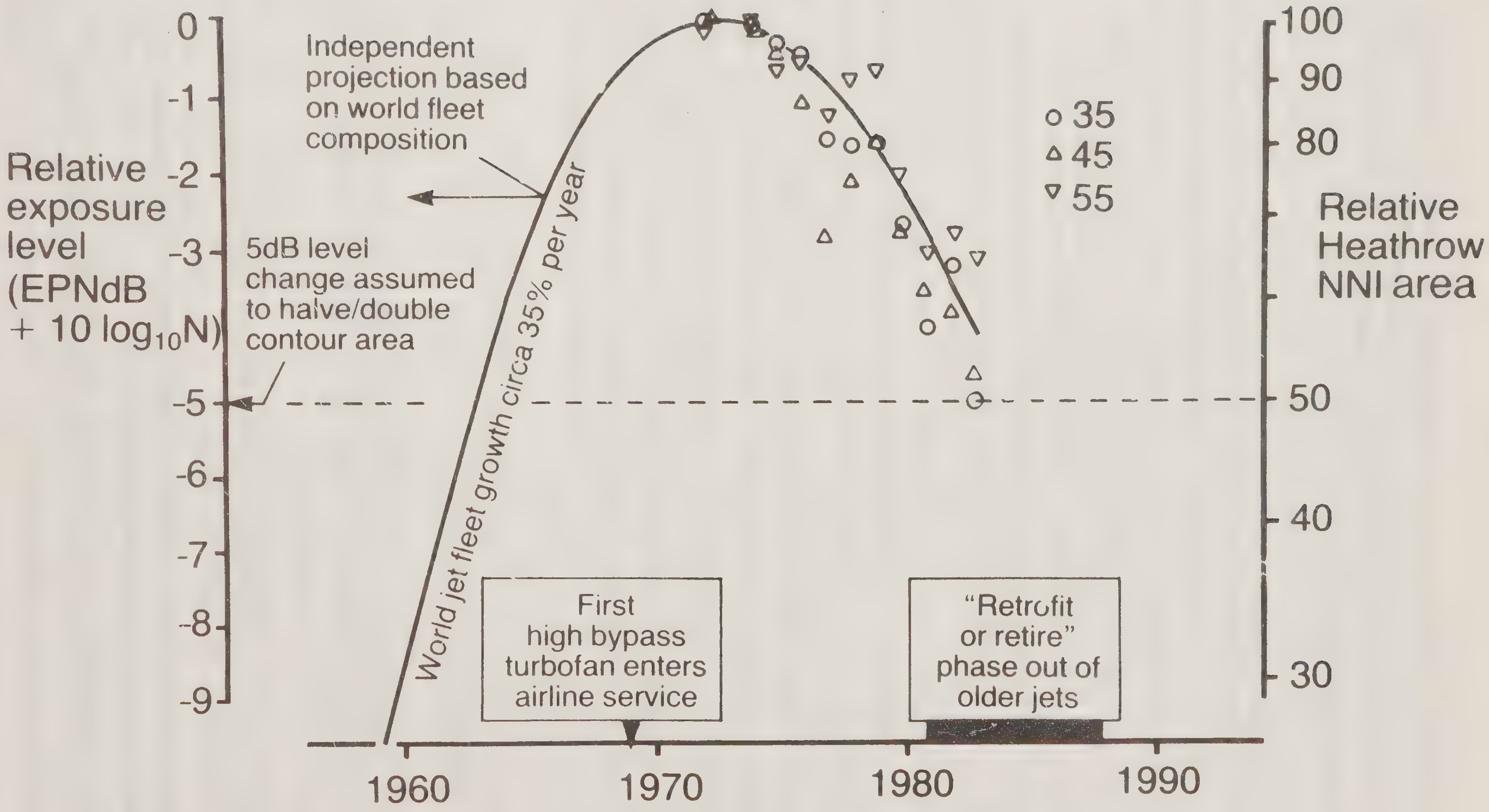
During the 1960s, the period of fastest growth of the jet fleet, environmental lobbies spurred governments to take positive action against the industry. In 1969 there started a series of legislative manoeuvres that have now grown to embrace all facets of air transport[1]. Whilst the resulting strictures only tend to enforce capabilities that industry has already developed, they do divert considerable attention away from the primary research and development that actually improves the situation. Currently half of the industry's specialist manpower is directed at ensuring that current production aircraft meet certification requirements, whilst the other half is attempting to improve the situation[2]. Nevertheless, the industry has made great strides, for aircraft noise



1. Free World Scheduled Jet Powered Fleet Size



2. Progress of Aircraft Noise Control



3. Fleet Noise Exposure Projection Compared with Published NNI Contour Areas for Heathrow

levels have fallen some 20 dB since the early days of the pure jet and low bypass powerplants (Fig. 2), despite large increases in the carrying capacity and range of individual types.

This huge reduction has not yet been fully appreciated at the airport, for two very good reasons. Firstly, the life cycle of a commercial transport aircraft type can be anywhere between 25 and 40 years, making the airlines reluctant to invest capital in newer technology until they are forced to do so for sound economic reasons. Secondly, the individual noise reductions have been partially offset by the increase in aircraft numbers, and hence movements. The simple view of the situation is presented in Fig. 3, where the world fleet composition has been allied to the typical noise levels of different types on take-off to construct a noise exposure trend. This shows a very steep rise during the 1960s, compatible with the known early history, followed by a peak in the early 1970s and then a steady decline as high bypass technology spread throughout the fleet. Whilst the projected decline over the past decade is in remarkable agreement with the UK Noise and Number Index contour areas for Heathrow that are published annually by the Department of Transport, the overriding question is what is likely to happen to exposure patterns in the medium to long-term future.

NOISE EXPOSURE PROJECTIONS

There are several key issues surrounding the validity of any forward projection of airport noise exposure. High on the list are:

- The rate of growth of the world fleet (i.e. the frequency of operations).
- The composition of the world fleet (in terms of technology/noise standard).
- The validity of the noise exposure index used.
- The economic climate.

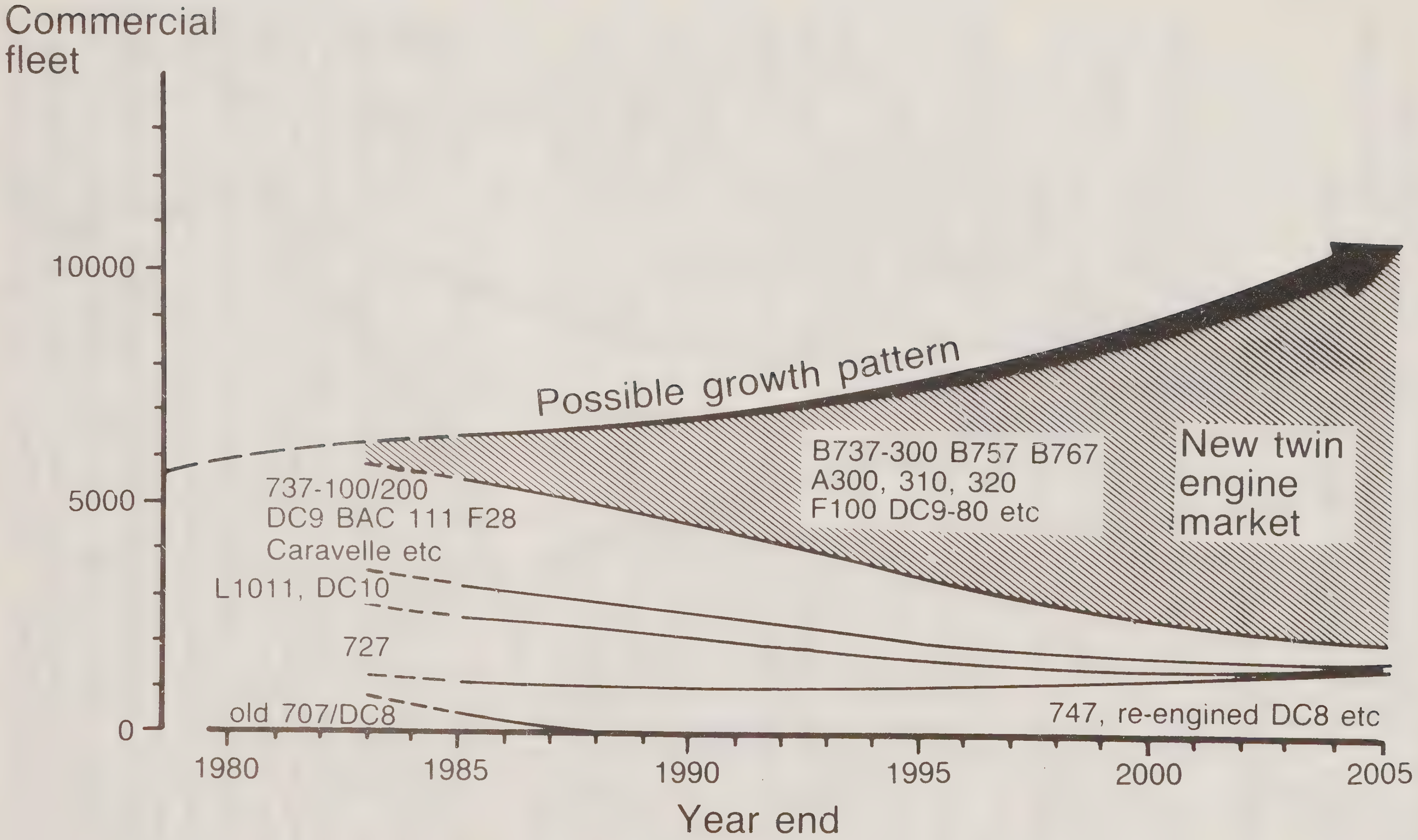
As regards the last item, there is no doubt that a thriving economic climate is a breeding ground for environmental activity, justified or unjustified. This is one element that cannot be predicted, and hence it is not certain whether the lower level of public pressure in recent years has been a function of the world recession or whether it is a genuine reaction to the introduction of quieter aircraft.

As regards the other aspects, we can attempt to make a reasoned forecast. In respect of the size of the fleet, industry forecasts anticipate a surge of new purchases during the latter part of this decade, as the world economy comes out of its current recession, with the average growth rate through to the end of the century being in excess of 5% in terms of annual deliveries, in cash terms[3]. This does not necessarily equate to numbers of aircraft, for the tendency is to produce marginally higher capacity and more refined (expensive) aircraft to replace the previous models. Also some of the sales will be to cover replacements for the existing fleet. It is more reasonable, therefore, to assume a rate of growth of numbers of aircraft of something like half the sales value, say 3%, which would produce a commercial scheduled fleet of just short of 10,000 units at the end of the century.

As to the fleet's composition, we can be fairly dogmatic. Although the recent fall in the price of aviation fuel has allowed the airlines to delay their conversion to new and more fuel efficient powerplants, the "old technology" aircraft utilising low bypass engines will disappear progressively over the remainder of this century, certainly in the context of operations at large noise sensitive airports by the major airlines who launch the new types of aircraft. Equally, the virtual disappearance of the trijet, witnessed by the closure of the Boeing 727 and Lockheed L1011 production lines, and the near closure of the DC10 line, is likely to produce a radical change in the shape of the world fleet. Great interest is being shown in the use of twin engined aircraft on longer routes, a situation that has hitherto not been permitted by the certificating authorities[4] who, for safety reasons, closely control the distance that a two engined aircraft has to be from a diversion airport. Air Canada used its Boeing 767 aircraft between Toronto and the Caribbean in late 1983, and El Al crossed the Atlantic between Montreal and Tel Aviv early in 1984. Recently both Air Canada and TWA[5] began to operate regular scheduled services between North America and Europe. It is highly probable that the extremely good reliability rates of modern turbofan engines will permit the wider use of twin engined aircraft on those routes hitherto the exclusive territory of the three and four engined aircraft, and there must therefore be some doubt as to whether we will see a re-emergence of the three engined aircraft.

This being so, the remainder of the century could see available only one large aircraft with more than two engines, the Boeing 747, which will continue to sell to operators who require high capacity long range capability. Much of the remainder of the market will comprise twin turbofan engined aircraft, which are the quietest of the modern breed. The range of twins on current offer is formidable, encompassing three marques of Airbus, the Boeing 767, 757 and 737-300 series, the new Fokker F100 and the developments of the Doyles MD-80 (re-engined DC9). The likely market for these twin engined aircraft, which may embrace the new open rotor "propfan" concept now in the research phase, is enormous, as is illustrated in Fig. 4.

This spread of modern turbofan technology into the smaller twin market will produce an appreciable lowering of noise levels, for the older twin/trijets comprise over half the existing fleet and account for much of the noise problem at major airports. Hence, we can expect a continuing improvement in the airport noise environment as this sector of the market is replaced by vastly quieter types. The problem is in determining whether the increase in numbers of aircraft will offset, or more than offset, the progressive lowering of absolute noise levels.



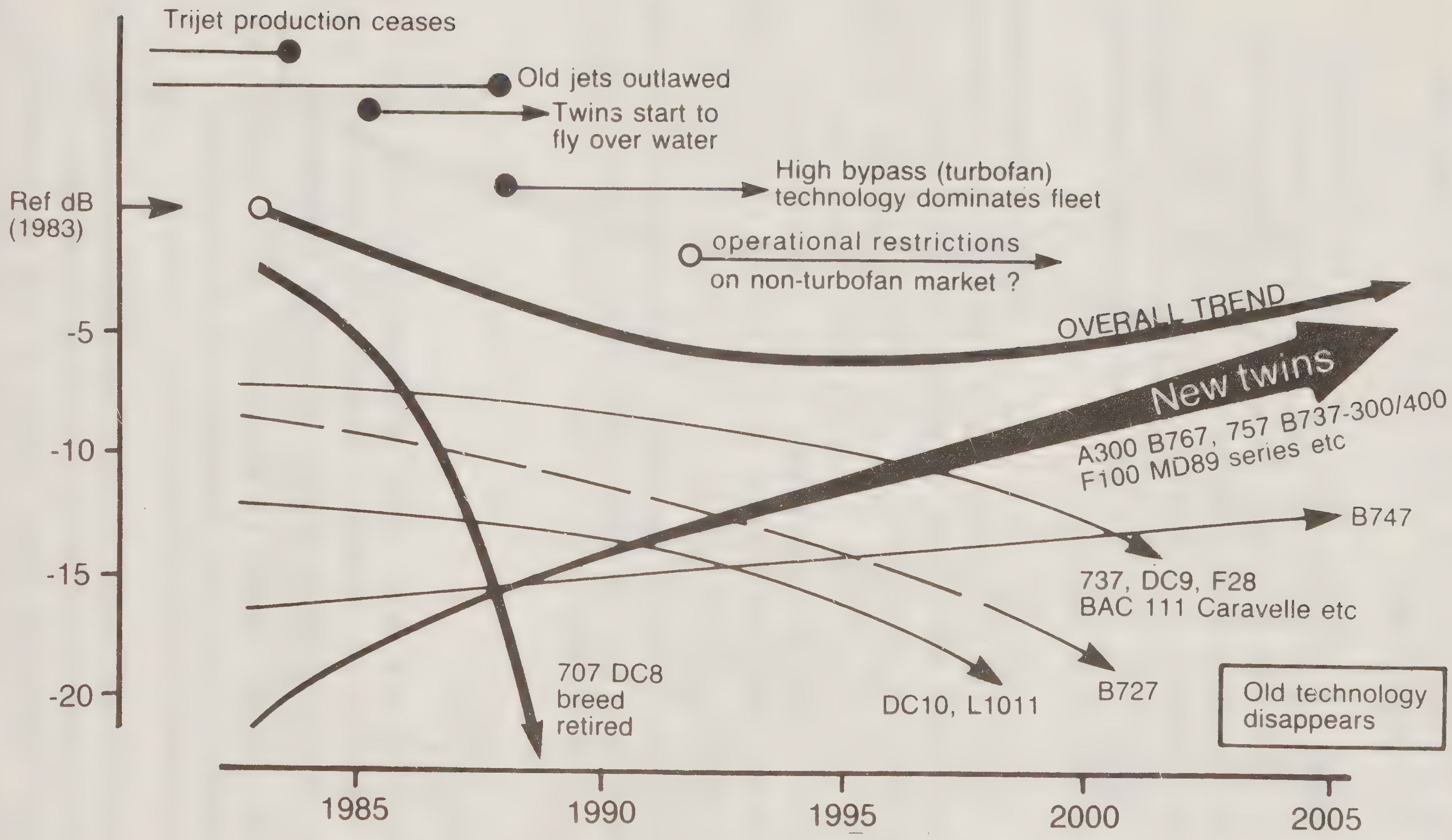
4. Probable World Fleet Composition through to the End of this Century

In this respect it is very important to examine the relevance of noise exposure indices used around the world, and in particular the interpretation placed upon the "number of movements" part of the equation.

NOISE EXPOSURE INDICES

The first major noise exposure index, the UK Noise and Number Index[6] (NNI), accounted for the impact of frequency of operation by the addition to the average noise level of the product of ($15\log_{10}N$), where N represents the number of movements. The factor of 15 was generated in the early 1960s, at a time when jet aircraft were extremely noisy, and airport communities had not become used to the much higher frequency of operation. This factor, as used in the NNI, is now under serious criticism and, in the author's opinion, should be modified to fall in line with the lower factor of 10 used more generally, and in particular in the USA where the noise problem has been severe for many years. Even then, one wonders whether a reduction from 15 to 10 is adequate in a climate of falling noise levels. Clearly, when aircraft become sufficiently quiet as to merge with the everyday background level, the number element is meaningless, and it may well be that by the end of this decade a value closer to 5 might be more appropriate.

Whilst discussion of the value attributed to the N factor might seem academic, its impact on the planning of future activity within the industry is critical. If we use a factor of 10, and make a long-term prediction on the basis of around 3% fleet growth, allied to the progressive introduction of modern technology, we produce a scenario that paints a gloomy picture for the future (Fig. 5). Assuming constant technology, that is, no further reduction in noise output per pound of thrust installed on new aircraft, there is a continuing decline in airport noise exposure through the next 5 to 10 years, beyond which there is an upturn dictated entirely by the number of twin engined aircraft likely to be introduced into the world fleet. To offset this increase, the



5. Projected Airport Noise Exposure Trend

subsequent decade would require a basic reduction in the noise from new aircraft of some 3 or 4 dB, simply to maintain the status quo.

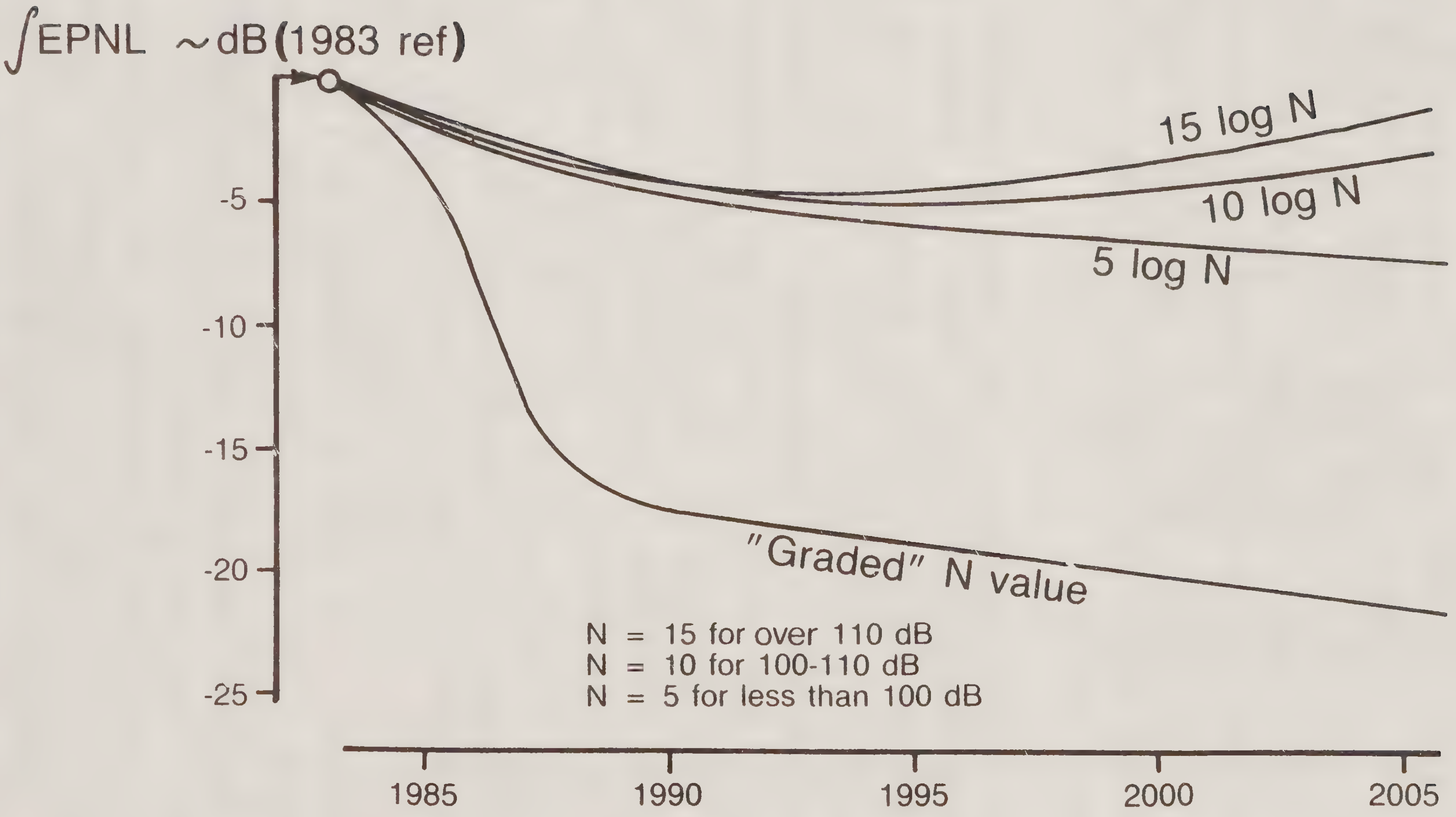
Alternatively, if we take the view that the N factor should reduce along with the reducing noise level, a completely different picture emerges. Illustrated in Fig. 6, the upswing from 1995 under 15 or 10 log assumptions becomes a progressive reduction using a 5 log factor, and a dramatic reduction if the factor is "graded" between 15 and 5 with time (or, more precisely, with absolute noise level).

So, what do we believe? The span of possibilities ranges from one of doing no further noise research and development, a very cost effective solution to the industry, to planning for a re-emergence of the noise problem in the late 1990s. As of today, the industry is forced to take the pessimistic view, for it takes many years for findings of research programmes to be applied to the product line, and even longer to influence airport noise exposure values. Since today's findings will dictate the noise standard of aircraft being produced in 10 to 15 years time, any further necessary improvements will need to be identified in the near-term future. This leads us directly to considering the current status of aircraft noise control.

TECHNOLOGY STATUS

The technology has made great strides since the early days of the pure jet engine. Whereas 20 years ago there was only one overriding source of noise demanding attention, that resulting from the jet mixing process behind the engine, today at least six major sources of engine noise all vie for dominance in the various phases of operation into and out of airports.

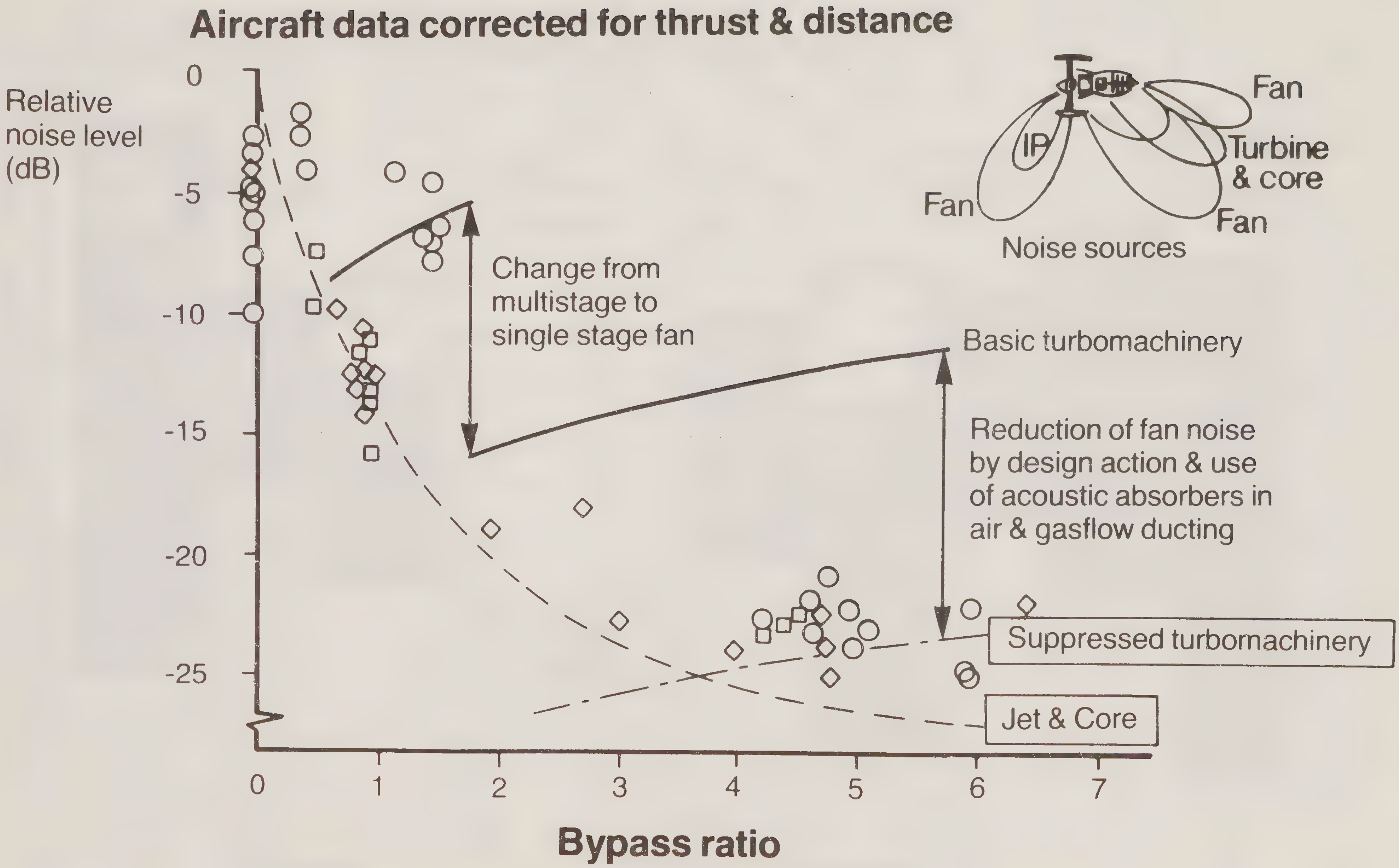
This situation has been created not only as a result of successful research efforts, but also from the significant change in basic cycle of the gas turbine powerplant. As materials technology has permitted, the



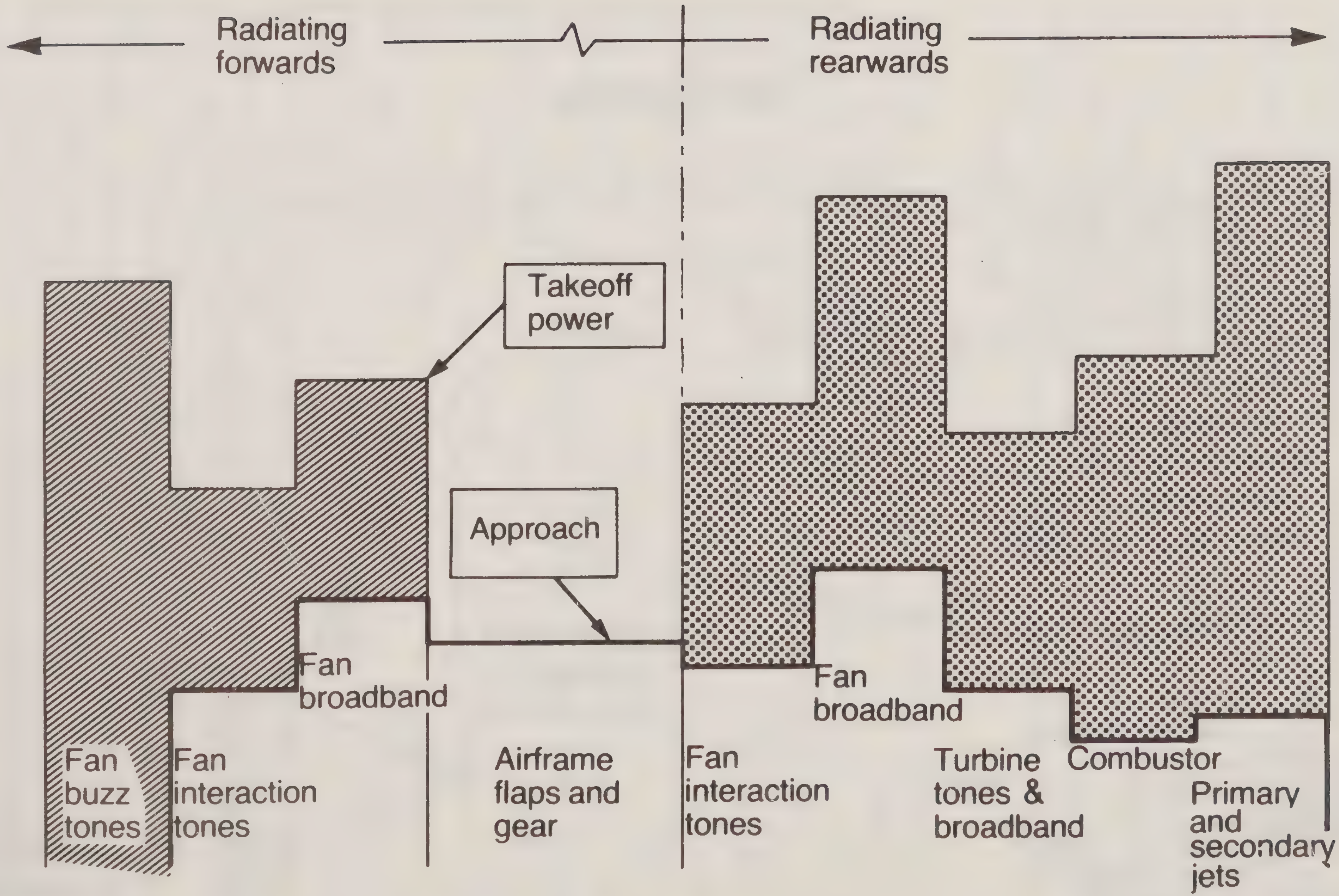
6. Impact of Different Assumptions Regarding the Significance of the Number of Operations

achievement of higher and higher efficiencies and temperatures in the core of the engine has led to the power extraction process being turned to greater propulsive and fuel efficiency in the development of the turbofan. In this type of engine almost five times as much air is used to generate the same thrust as the single stream pure jet, but with much higher airflows and much lower exhaust velocities. Consequently, the jet mixing noise element has diminished in importance from one of overriding concern at all phases of operation to being only marginally dominant at full thrust, and of even lesser importance during approach to land (Figs. 7 and 8).

The fact that all sources are now, broadly speaking, of similar importance is the direct result of success in tackling the significant internal sources over the years. As Fig. 7 implies, the modern turbofan would be little quieter than the early pure jet and low bypass engines had it not been for major improvements in the understanding and application of noise control techniques to the turbomachine, in particular the fan and turbine modules. Compared with the noise generated by the early turbofans, as exhibited by many Boeing 707s still in service, the ear-shattering fan whine has been subdued to near inaudibility. Figure 9 indicates how this has been achieved. The reduction of the number of stages in the fan combined with an aerodynamically "clean" inflow has eliminated many of the interactive sources, whilst the application of detailed research findings has been augmented by use of acoustic liners in the intake and the bypass sections. The need to go further will be dictated by the degree of success in other directions. This must necessarily include the noise sources that are associated with the aeroplane fuselage, wing, flap and undercarriage structures. These can be very significant in the approach-to-land phase of operation, even to the point of becoming dominant if there is a high degree of powerplant noise suppression. There is no evidence that the airframe manufacturers are taking on board the responsibility for implementing airframe noise reduction programmes.



7. Engine Noise Source Variation with Bypass Ratio



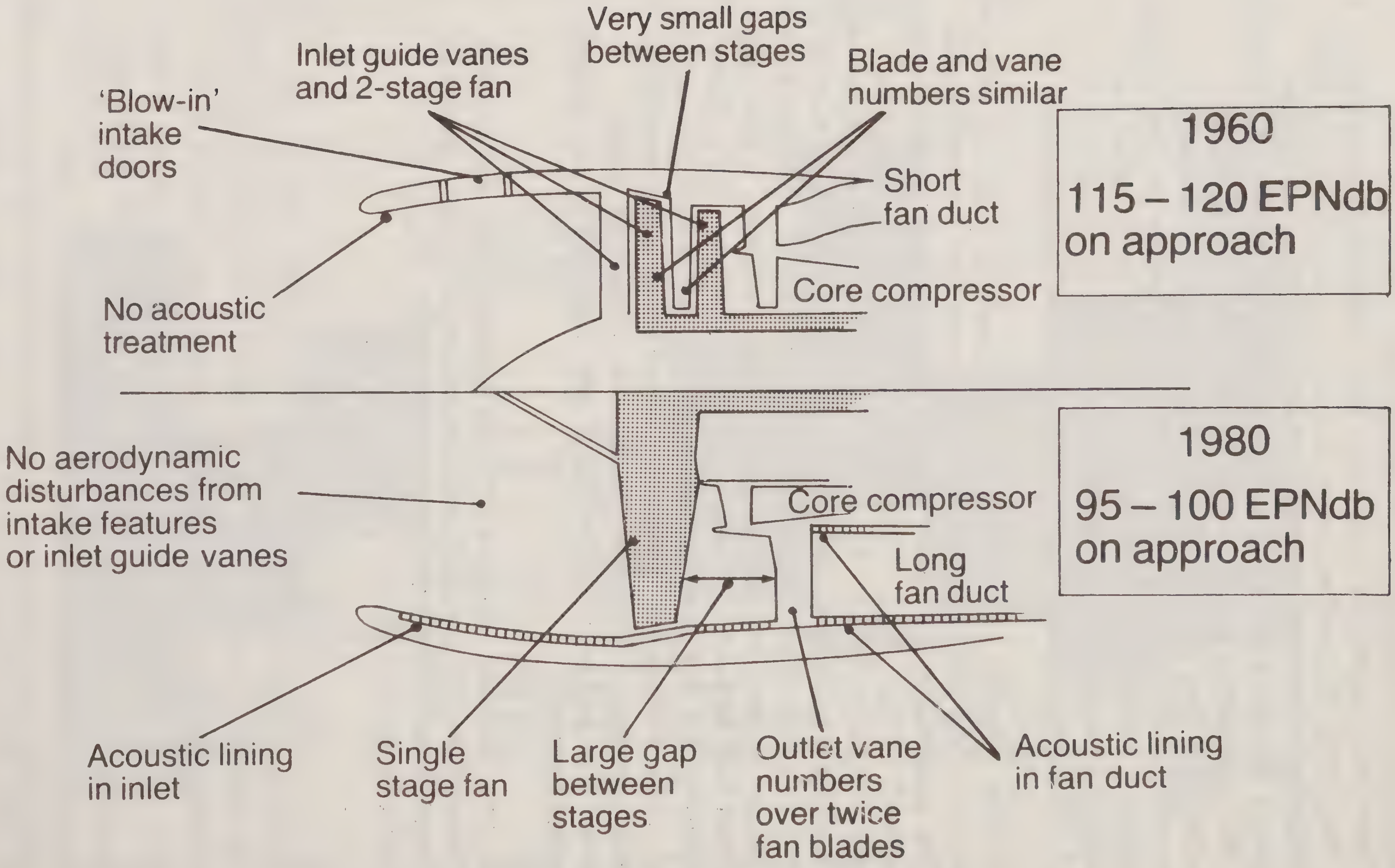
8. Sources of Noise in the Modern Turbofan Powered Aircraft

Conversely, my company is continuing to carry out fundamental research into all the remaining sources. At our facility in Ansty, near Coventry, we explore the fundamental generative mechanisms of fans. At the national Noise Test Facility at RAE-Pyestock, Rolls-Royce and RAE research teams conduct similar work on the turbine and the jet exhaust. Advances in acoustic absorbers are being explored in programmes at Derby and Pyestock, whilst full scale engine testing remains a critical element, and now takes place on a purpose built new facility at Hucknall in Nottinghamshire.

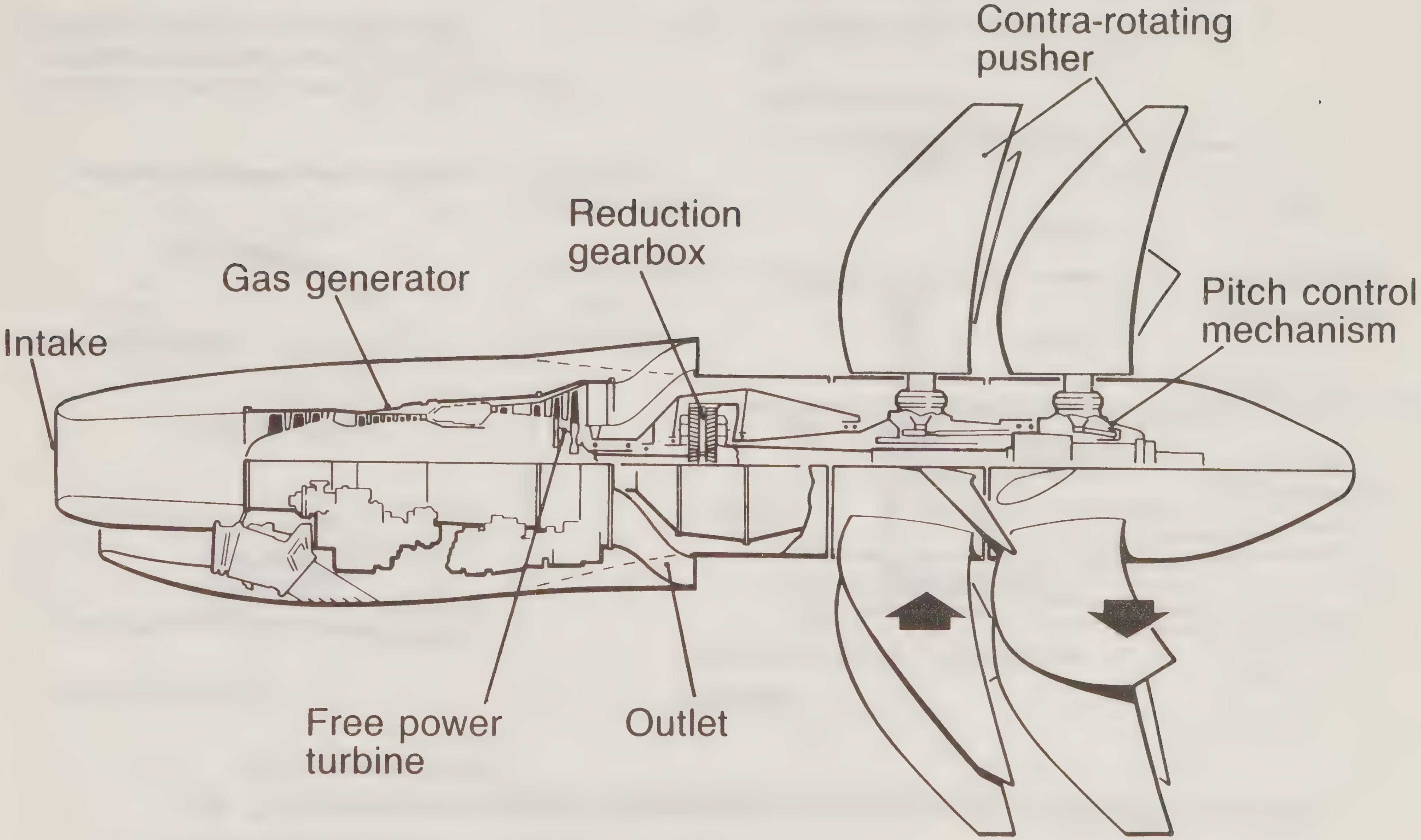
As to the longer term future, the possibility of further gains in fuel efficiency may well see the re-emergence of the propeller in the form of a highspeed open rotor or "propfan" (Fig. 10). This presents some formidable research challenges. By definition, the open rotor has no fan duct surrounding it in which acoustic material might be contained, and the evidence today suggests that the noise from individual open rotor stages, plus any interactive effects, could dictate whether this form of propulsion is a feasible reality for aircraft appearing later this century. Research studies are progressively assuming greater importance as the industry moves towards the project definition and demonstrator stages of development.

As to the general status of the technology, there are many examples of persistent research activity yielding meaningful and profitable results. It is worth reflecting on a few of them.

- In the 1970s we followed up the activities of Cambridge and Southampton Universities in techniques for source location[7]. As a result of an interactive collaborative effort, these processes, which rely upon interrelating the signals detected by an array of microphones, are now used regularly in component research and in full scale engine tests. The output displays, both visually and numerically, the magnitude and position of the various sources present at any given frequency (Fig. 11). Use of this



9. Evolution of the Quiet Turbofan Engine

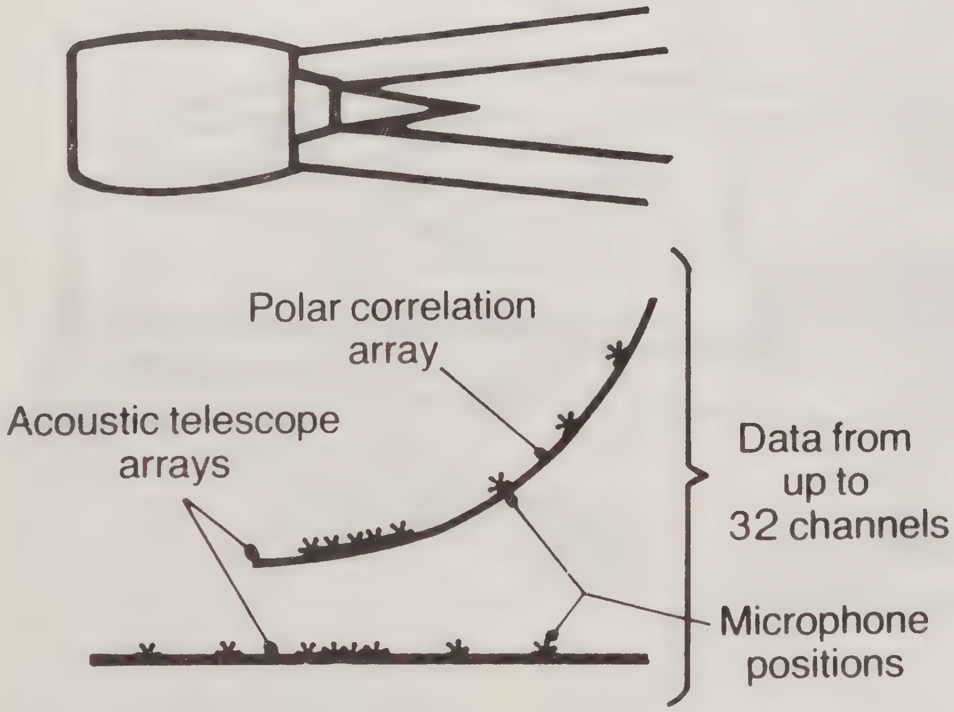


10. Possible "Open Rotor" Propeller Configuration

Objectives

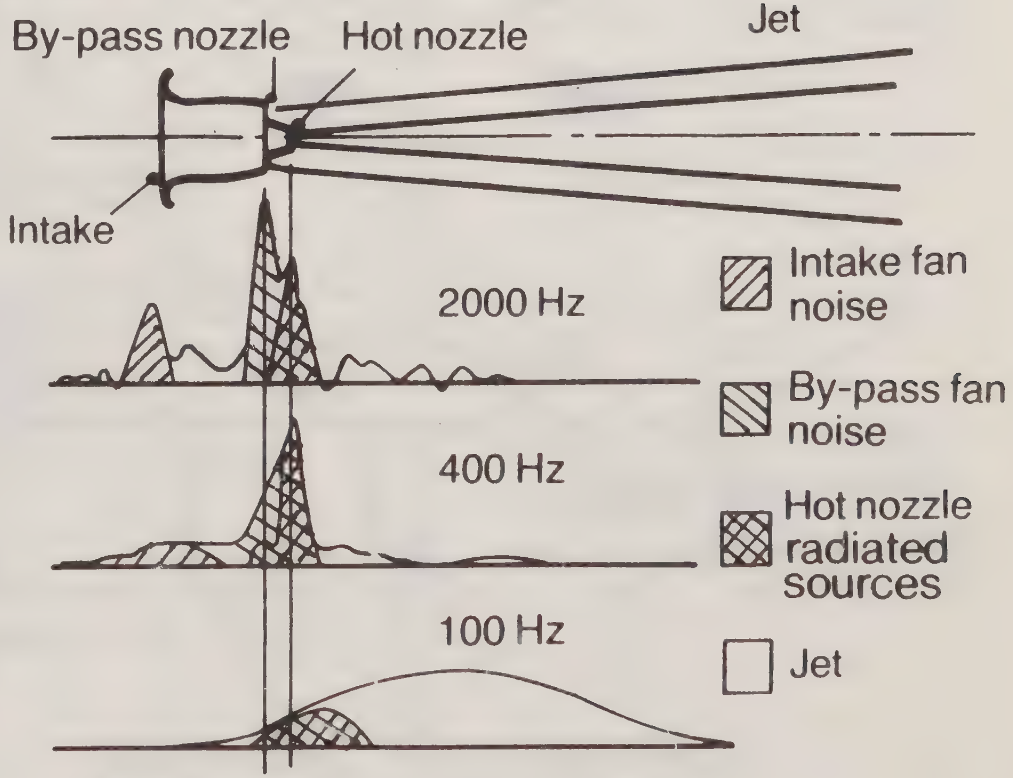
- To identify and quantify the relative importance of different sources of engine noise

Measurement



Sources located by time delaying and cross correlating signals from an array of microphones to scan axial position

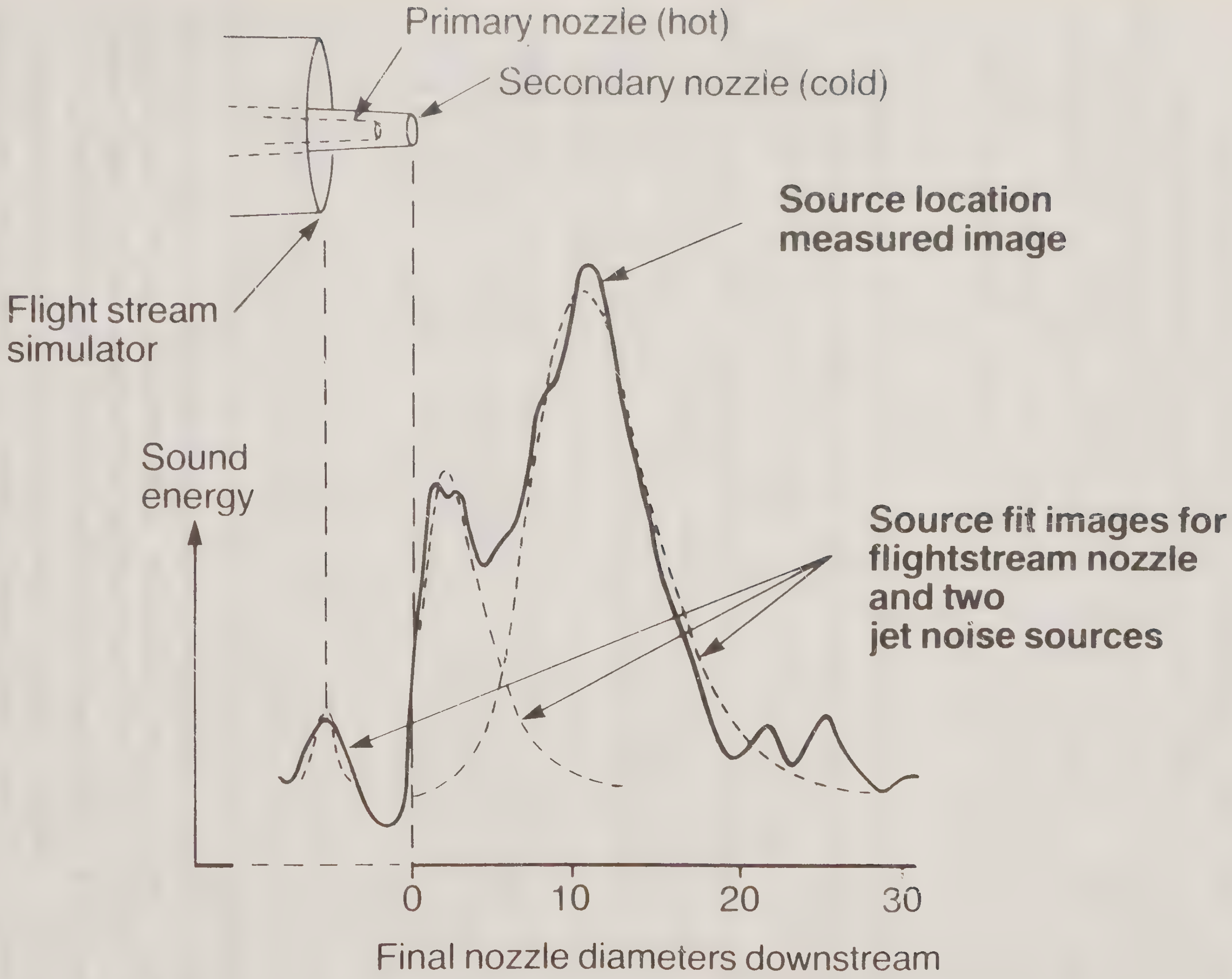
Results



Applications

- Component research tests
- Static engine tests
- Flyover tests to study flight-effects

11. Source Location



12. Independent Near-Nozzle and Downstream Sources of Jet Noise

technique in model scale research has indicated the existence of at least two major noise producing regions in a turbofan jet (Fig. 12). Although previous consideration of the jet structure had promoted such concepts, we now have available to us the first real demonstration which opens up the chances of quantifying jet sources, examining the phenomenon of jet excitation and exploring the changes that take place between static and flight regimes. Since jet noise is the ultimate "floor" in powerplant noise, this could prove to be one of the most significant developments in the past 20 years of jet noise research activity.

- In the Fan Research Facility at Ansty we observed a significant departure from developing correlations and design rules when testing the new wide chord fan for the RB211-535 and Tay series of engines. Whilst this fan was expected to be fundamentally noisier than conventional designs, it exhibited a significantly lower interaction tone level than expected. This was finally accounted for by a consideration of the modal patterns of propagation, and attributed to a very natural high transmission loss through the fan stage when the sound wave is propagating counter to the direction of rotation of the fan[8]. This observation is now being put to benefit in the design of all our new fans.

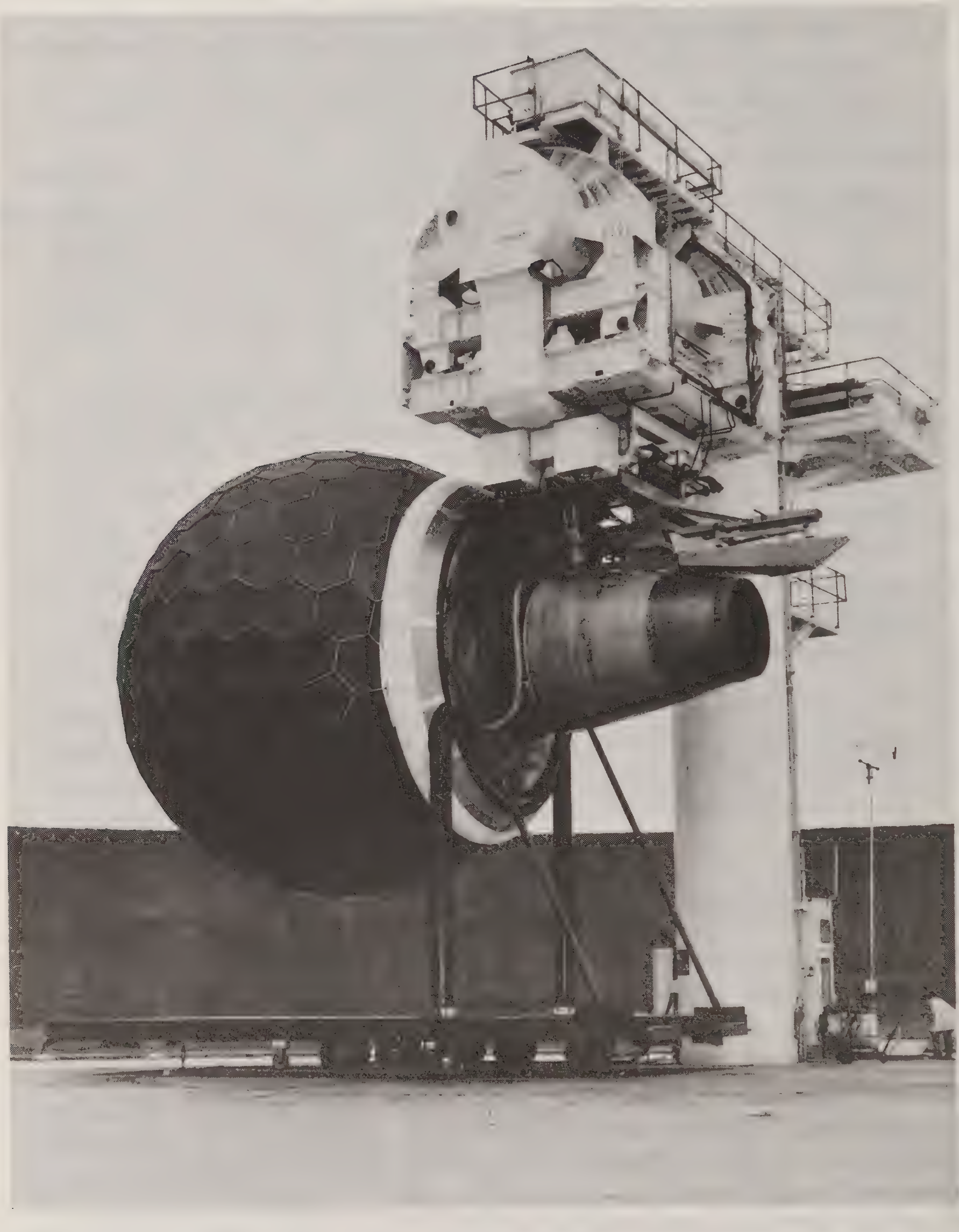
- Research findings at Pyestock[9] during the course of a 10-year multi-element programme investigating the effects of motion and aircraft structures on the generation, radiation and propagation of engine noise have led to a much fuller understanding of the effects of installing and operating an engine on an airframe. The test programmes involved model and full scale static tests, flight tests and co-operation between industrial and government research organisations both in the UK and overseas. Whilst at times the effort involved in bringing all the programmes to fruition seemed daunting, the overall result has been a predictive capability which allows us to account for most of the known effects of installing a powerplant on to a major structure, and for the effects of forward motion.

- In the specific context of forward motion, the understanding of the effects of natural atmospheric turbulence on the generation of fan noise, first revealed by Rolls-Royce in 1974[10], led to the development of turbulence control structures for both rigs and engines which have resulted in a vast improvement in the relevance of static data. Such control structures are now a permanent feature of component fan noise facilities, and all modern open-air test beds are fitted with devices of the kind illustrated in Fig. 13, that used on our open-air facility at Hucknall. Their use is now opening up the use of static engine tests for certification, in lieu of expensive flight testing.

- The application of classical ray theory to the propagation of sound in engine ducting[11] has simplified by an order of magnitude the procedures for specifying acoustic treatment and quantifying its effectiveness.

- The application of signal analysis techniques to the constantly changing spectral character of noise from aircraft in flight is allowing us to separate tones at almost identical frequencies. This has proved of particular use in the past year in identifying the relevance of interactive effect between counter-rotating propeller stages.[12]

Overall, it can be assumed that the industry, particularly in the UK, is still well placed to pursue active research programmes, and in fact over the past year my own company has actually increased its effort in this direction. Whilst this is consistent more with the need to satisfy requirements now being placed upon operators at regional airports, it by no means indicates that we believe the general problem to have been solved. Indeed, if the propfan is to emerge as a reality, we will need to pursue open rotor research alongside our existing turbofan based programmes.



13. Turbulence Control Screen for Static Engine Testing

FUTURE OPPORTUNITIES FOR NOISE CONTROL

There is little indication that forward projections of the overall airport noise situation are being taken seriously across the spectrum of interested parties.

In the legislative arena, the structure of Noise Certification is now so rigid that it will take an enlightened administration to alter course and provide the essential element of incentive that is so obviously lacking today. Providing an aircraft passes its Noise Certification examination, it is generally irrelevant whether it does so marginally or handsomely. The need to produce levels lower than the standards demanded in Certification is dictated almost entirely by requirements at particular airports. As an example, the FAA-owned Washington National Airport in the US capital city has a night-time curfew dictated by demonstrated aircraft noise levels. Recently, the latest Rolls-Royce RB211-535E4 powered Boeing 757 broke this barrier. It is the first large commercial aeroplane to do so, and 535E4 operators now have on offer the flexibility of using that airport at night. It is clearly wrong that the Certification process should ignore the realities of operation, and continue to be an examination on an archaically structured basis. The key element of incentive needs adding to its ingredients[13].

Such incentive could take the form of encouraging the development of "quiet flying" techniques (rather than the rigid fixed-profile examination), in both take-off and approach phases of operation. If encouraged, by recognition in the Certification process, the industry would respond very quickly with low-drag/low-power flight profiles, and promote additional research into areas that might enhance current noise control techniques.

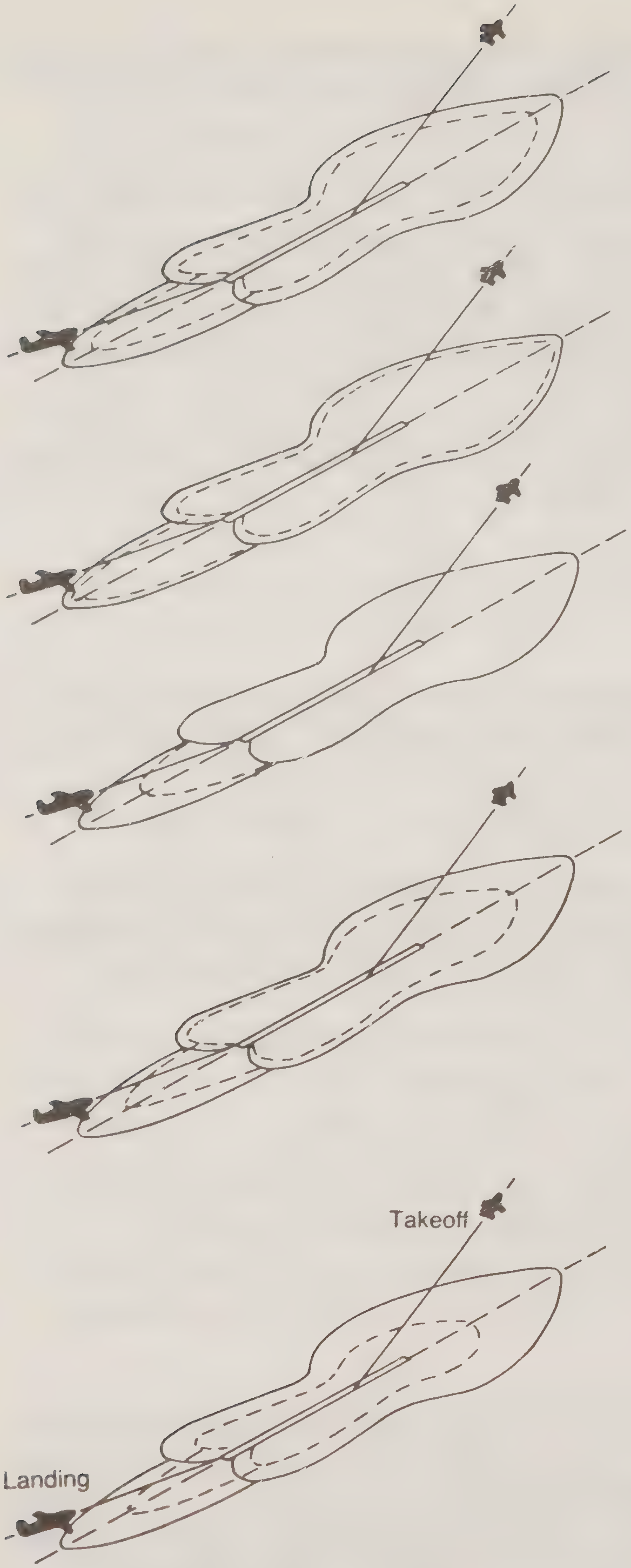
By reference to Fig. 14, some possibilities for further noise relief around airports that can be identified are:

- Any reduction in noise at source, the province of the engine manufacturing industry, is automatically read across pro-rata into the overall size of any given contour of constant annoyance. As an example, a 3 dB reduction in source noise reduces overall contour area by around 30%.

- Equally, any improvement in aircraft performance, eg, in the capability to increase the lift efficiency of the wings, reads across into contour areas as a pro-rata noise reduction contingent upon the lower thrust requirements or improved climb gradient. Conversely, the aeroplane can be made more "productive" at a given noise contour area, by being able to carry more people or freight, or to fly further, in one given operation.

- The use of "managed" low-drag/low-thrust approach profiles has proved of very great benefit. The delaying of flap and landing gear deployment until close to the airport reduces the thrust requirement, and hence noise, substantially. This form of technique has been important in the operation of Concorde, and has been more widely implemented at airports like Frankfurt. Other airports have not followed suit, using the excuse of air traffic control complexity with varying aircraft speeds. Again, the Certification process, being deliberately based on a noisy fixed configuration, fixed profile measurement at a fixed distance, cannot recognise these benefits, and is a disincentive to the aeroplane manufacturer to scheduling optimised managed-configuration profiles into the modern automated aircraft control system.

- The installation of the powerplant onto an airframe is of great significance in terms of reflections/ amplifications of the noise produced by the powerplant, and in generating new sources where there is an interaction between the wing and the engine exhaust. There is evidence freely available from research in the 1970s to show that optimisation of the installation could quite easily reduce noise levels by 3 dB, effectively removing the noise from one engine on a twin, albeit at some performance cost. The incentive



3dB reduction in source noise reduces overall contour area by 30%

10% reduction in thrust required to give same aircraft performance reduces contour areas 10%

"Managed" (low drag) approach procedures reduce landing contour area 30-40%

Avoiding amplifications from installation features and selective use of "shielding" techniques could reduce areas 30%

Reasonable overall potential is in the region of a 60% contour area reduction, or around 6dB lower levels in the community

14. Opportunities for Further Aircraft Noise Control

to examine ways in which the performance penalty might be eradicated is not present in the Certification process.

Overall, given the incentive, there is the potential for a further 5 dB reduction in aircraft noise around airports. This may or may not be necessary, depending upon the real climate when the old technology has worked its way out of the fleet. However, if there is a requirement for further noise reduction in the 1990s, then every possible avenue of approach should be explored, and this requires continuing activity in the industry for at least the remainder of this decade.

CONCLUSIONS

In closing, it is appropriate to re-iterate the status of aircraft noise control, and the prospects for the future.

There is no doubt that the industry has made great efforts to alleviate the situation produced by the introduction of the jet engine a quarter of a century ago. Noise exposure values at operationally "saturated" airports have fallen some 50% in the last 10 years.

Encouragingly, the pipeline already contains further improvements throughout this decade, but it is possible that airline growth in the 1990s may negate the impact of technological advances. It is tempting to believe that the problem is solved, and the worldwide reduction of government support to industrial noise control research is disappointing. It may prove to be a short-term expedient which is mortgaging a healthier future situation.

Moreover, Aircraft Noise Certification is diverting far too much attention from the fundamental understanding of the physics of noise generation and control. It is only as a result of a thriving research activity that further inroads into the subject will be made. The following specific issues are well worth noting:

- Credibility of recognised noise exposure indices is vital in determining whether the longer term aircraft noise problem is "solved", or whether fleet expansion will aggravate the situation in the 1990s.

- Pressure for further noise improvements will continue, if only in the context of locally imposed requirements at airports in heavily populated areas, and the desire to expand night-time operations.

- The Noise Certification process is too rigid and too complicated; it should be reshaped to provide the elements of incentive and flexibility that are so clearly missing today. Sensibly framed, certification could promote competition amongst the manufacturers to achieve the lowest possible noise levels.

- The open rotor ("propfan") concept will bring new noise control challenges to the industry, which will need to be solved before this mode of propulsion will be acceptable to the passenger and public alike.

- The UK is well placed to pursue noise research on a broad front. This capability should not be sacrificed on the altar of expediency in a recessionary period if any resurgence of the airport noise problem is likely in the 1990s.

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SCARBOROUGH

– NOISE –
ENTERTAINMENT NOISE

– By –

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1. INTRODUCTION

It has long been established that high noise levels can cause damage to hearing. The earliest investigations into this subject were focused on problems associated with industrial exposure. In the latter years of the nineteenth century research was published which clearly demonstrated that boilermakers were more likely to suffer deafness than those enjoying less noisy employment. It was not until the 1960s that the subject seems to have been given adequate consideration. In 1970 a definitive work[1] was published in which a number of important conclusions were reached:

a) noise exposure can be described by a single number, based on dB(A) and time on an energy basis, so that the effects of complex exposures can be assessed;

b) hearing deterioration can be predicted, in a general way, by consideration of noise exposure;

c) temporary hearing loss caused by high noise levels is associated with permanent hearing deterioration.

Acceptance of hearing damage caused by occupational exposure has led to a developing interest in the likelihood of similar effects being produced as a result of leisure noise. Concern has been greatest in relation to the highly amplified sound associated with 'pop' music, but many other leisure activities also have related noise exposure. In most cases exposure to high sound level is not only self imposed but is also beyond legislative control. It is therefore important that consideration be given to the most effective manner of educating those exposed to the greatest risks.

2. NOISE AND HEARING DAMAGE

Research on industrial noise exposure and associated hearing damage confirms that hearing loss is related to the total energy of the noise received by the ear. Expected hearing loss is determined not only by the noise level or by the duration of exposure to noise, but by the combined effect of these two components. The same degree of hearing loss can result from a short exposure to a very loud noise or from prolonged exposure to a less intense noise level.

Individuals do not respond in an identical manner to noise exposure. Some people seem to have ears that are more sensitive than others; a noise dose which causes a measurable effect on one person apparently causes no effect on another. Hearing loss can, in any case, result from factors other than noise exposure. However, there is general agreement[2] that if the noise level does not exceed an average of 85 dB(A) over a working year, the level can be considered safe for most individuals.

Noise exposure from recreational activity is unlikely to be as significant as occupational noise exposure. From information contained in the Burns and Robinson[1] study it is possible to calculate (Table 1) the noise dose which would be equivalent to 90 dB(A) for a full working year.

Table 1

SOUND LEVEL EQUIVALENTS

Duration of exposure (hours per day)	8	4	2	1	½
Maximum equivalent noise level dB(A)	90	93	96	99	102

3. EXPOSURE ASSESSMENT

The Health and Safety Executive has recently published a major review of literature which considers all aspects of damage to hearing arising from leisure noise[3]. An overview of the current situation is given based on the contents of 582 papers. Almost one third of published work is concerned with rock or pop music but a wide range of other sources are also identified. A position statement on each of the main noise sources is contained in the following paragraphs.

3.1 Discotheques

The best and most well researched study of sound levels and exposure in discotheques is to be found in a comprehensive report by Bickerdike and Gregory[4] - An evaluation of hearing damage risk to attenders at discotheques. This document contains a wealth of information on sound levels, sound distribution patterns, octave band analyses, age and attendance patterns, noise immission ratings and Leq values, and estimates of hearing-damage risk.

The general impression given by the range of published work on discotheques is that sound levels in individual premises are consistently at a particular level but that the range of levels measured at different premises is considerable. Bickerdike and Gregory[4] report a range 87-113 dB(A); Cabot 82-95 dB(A)[5] and Fearn 92 dB(A)[6]. It is interesting to note that one researcher[4] has detected an increase of about 5 dB(A) during the course of performances.

One of the pioneer researchers into hearing damage suffered by attenders of discotheques and rock concerts is Fearn. It was his initial studies, in the early 1970s, which led the then Leeds Borough Council to seek to control sound levels in places of public entertainment (Appendix 1). Fearn has, for the last fifteen years, been involved in a range of studies focused on hearing risk to young people.

Having reviewed all available evidence on hearing studies in young people the Institute of Hearing Research concludes[3] that no survey has shown a mean difference between non-noise exposed and noise exposed groups of more than a few decibels. The long term implications are said to represent only a marginal risk to hearing due to rock/pop music exposure.

3.2 Live amplified rock/pop music

Measurement of sound levels at rock concerts seems to have attracted considerable interest but limited useful data. Perhaps it is a way of getting in without paying!

The Institute of Hearing Research[13] has assessed all of the information and concludes that the most likely range of sound levels near the centre of a live music pop concert is between 101 dB(A) and 105 dB(A). Several researchers have identified a variation of 7-10 dB(A) between the area near the stage and the rear of the auditorium.

The noise immission level experienced by concert attenders may be as high as 106 dB or as low as 82 dB. Lack of information on attendance patterns restricts the development of exposure estimates for various groups of attenders.

Pop musicians and their support staff are likely to experience more prolonged exposure than members of the audience. Noise levels measured in the vicinity of groups are in the range 90 to 130 dB(A)[3] although higher levels have been measured in practice rooms. Against this background it is not surprising to learn that significant numbers of rock musicians suffer from noise induced hearing loss or that their hearing loss tends to be appreciable.

3.3 Classical music

Noise levels associated with classical music are significantly lower than those experienced at pop concerts. Typically, levels in the order 75 dB(A) have been measured during supposedly 'loud' passages although Fearn[7] did determine the mean for a performance of the Berlioz Requiem Mass at 88 dB(A). The reason for the striking difference in noise levels is that classical music has never been reinforced by amplification.

Musicians receive, at worst, levels of 75-99 dB(A) Leq over short periods[8]; these levels equate to high 80s over weekly sessions. The risk to orchestral musicians is said to be slight[3] but consideration should be given to limiting periods of exposure or rearranging orchestra seating to reduce local sound levels. It remains to be seen if 'mere science' will overturn the long established disposition of the symphony orchestra.

3.4 Earphones and personal cassette players

Little research seems to have been carried out into the significance of individual noise exposure from 'personal hi-fi' systems. Typical levels appear to be in the range 62-103 dB(A)[9] - a weekly exposure of this level for two hours could contribute to material risks to hearing.

3.5 Arcade games

Noise levels in the range 84-111 dB(A) have been measured for common amusement arcade games[10]. Newer games tend to produce higher noise levels. No information is available on attendance but some players are said to stay all evening. Reference to Table 1 indicates that half an hour at 102 dB(A) is equivalent to the currently acceptable daily industrial dose. Noise from arcade games may be as significant as from rock music, but more data is required.

3.6 Fireworks

Public concern about fireworks has centred on the obvious horrific burns which result from accidents. Little general consideration has been given to risks of hearing damage although Swedish studies reveal peak levels in the range 125-126 dB(A) are produced by the "banger". No data on UK fireworks is available at the time of writing this paper. However, unless Scandinavian bangers have some unique characteristic, explosive fireworks may represent a real threat to hearing if misused.

3.7 Toys and toy guns

Swedish research[11] indicates peak noise levels between 153 dB to 170 dB at distances of 50 cm to 100 cm from the muzzle of toy guns. Used outdoors such playthings can produce dangerously high noise levels; if fired in close proximity to the ear the results could be traumatic[3]. No control is available except the prevention of sale of devices producing high peak levels.

Other children's toys produce high noise levels but information on this subject is limited.

3.8 Sports guns

Peak pressures of between 130-139 dB are produced[12] at the ear from the shooting of sports guns. Not surprisingly there is a difference of about 8 dB between peak pressure levels at either ear when a rifle is fired. It is generally agreed that firearm noise is damaging to the unprotected ear but there is limited research on the extent of exposure[3]. Investigations into hearing damage in hunters generally show a higher loss in the left ear, ie the side of the shoulder where the rifle is placed.

3.9 Traffic

Although literature abounds on various aspects of annoyance caused by traffic, little has been written about the effects of noise on vehicle users. It is generally held that it is so quiet in a Rolls Royce that the tick of the clock is intrusive (perhaps the builders of this car chose loud clocks) but generally interior vehicle noise is not considered by the car testers or mentioned in vehicle specifications.

Similarly, in the case of motorcycle noise most interest has been focused on the nuisance aspect of the machine. Nevertheless motorcycle noise also affects the rider, particularly at speeds exceeding 50 mph or journeys exceeding half an hour. The practice of silencer modification has a detrimental effect not only on the community but also on the rider. Surprisingly, helmets provide little attenuation, ranging from nil at low frequences to 20 dB(A) at high frequencies[3]. There is a balance between the need to protect hearing and the requirement for motorcyclists to be able to hear warning sounds but there seems to be room for some improvement.

3.10 Racing Cars

The RAC scrutineering limit for racing cars is 115 dB(A) at 5 m from the exhaust outlet at an angle of 45°. Measurements made at the side of a racing track are in the range 82 dB(A) to 107 dB(A) depending on vehicle type[3]. Spectators are kept about 15-20 m from the cars at major events for reasons of public safety but short term exposure in the high 90s may be experienced by enthusiasts near the track side.

No useful information is available on racing lawnmowers, go-karts or drag racers.

3.11 Model aircraft and boats

Environmental effects of model aircraft noise is the source of advice in the form of a Code of Practice under the Control of Pollution Act 1974. Noise exposure is more significant to the modeller, especially when engines are tuned and otherwise run indoors. Model aircraft engine levels, indoors, are reported as being in the range 106 dB(A) to 114 dB(A)[13]. Regular exposure to such levels could be dangerous to individuals[3], particularly those with significant occupational exposure to noise. Although not referred to in the literature, it is likely that model boat hobbyists would be similarly vulnerable.

3.12 Motor Cruisers

Results of noise tests on motor cruisers with onboard engines have been reported in the journal Motor Boat and

Yachting. A range of 92 dB(A) to 98 dB(A) has been measured in either the aft cabin or cockpit of cabin cruisers[3]. No information seems available on noise exposure from outboard engines.

3.13 Do-it-yourself activities

Motor mowers, chain saws, circular saws and other power tools can produce high noise levels, but little research seems to have been carried out into exposure risks.

4. PROTECTIVE MEASURES

Having considered typical noise levels from a wide range of recreational activities it is necessary to consider action which may be taken where risks have been identified. The scope of this paper limits consideration to aspects of protection which are of particular relevance to local authorities. Remedial measures are considered in the same sequence as sources were described in the previous section.

4.1 Discotheques

It is interesting to note that leading researchers into discotheque noise are associated with Leeds Polytechnic. In 1974 Leeds Borough Council sought to impose limits on noise levels on those premises covered by Music and Dancing Licences but the procedure was of limited success. Appendix 1 provides a summary of the experience. Bickerdike has produced a draft Code of Practice on sound levels in discotheques which contains valuable advice on all aspects of the problem[14]. In essence his suggested approach is to limit sound levels so that over the duration of an event the A-weighted Leq should not exceed 100 dB(A) at the nearest point to a loudspeaker accessible to the public. At no time should a 5 min Leq, measured at the same position, exceed 102 dB(A). Rest areas should be provided where the 5 min Leq does not exceed 87 dB(A); these areas should be at least one quarter of the total floor area. Loudspeakers should be distributed around the dance floor and no speaker should be within 2 metres of any point 1.6 m (ie head height) above the dance floor. Bickerdike goes on to suggest that risks of hearing damage should be identified by signs in the foyer and in literature made available to patrons. Unfortunately at the time that this Code of Practice was being drafted the Government was killing off the Noise Advisory Council who had commissioned the investigation. It is to be hoped that the publication of the Institute of Hearing Research review of the literature will reawaken interest in this subject.

The Greater London Council has also produced a booklet under the title 'Disco Rules OK?'[15] which contains brief notes on noise. It is suggested that noise levels should be controlled in order to minimise the risk of hearing damage to the audience, performers and staff and reduce as far as possible any annoyance to occupiers living in close proximity to the premises.

In order to protect patrons the GLC takes the view that the Leq for the opening period should be equivalent to 90 dB(A) for an 8 hour period. It is indicated by the GLC that if peak levels (measured with the meter on slow) never exceed the guideline figure by more than 10 dB(A) then the guideline will be met. For example, if premises are open for 4 hours the Leq is 93 dB(A) - the level measured on 'slow' should not exceed 103 dB(A).

To minimise noise disturbance it is recommended that the Leq for any period of entertainment or rehearsal outside the windows of the premises should not exceed the Leq for a comparable period when the discotheque is not operating. Furthermore, no sound from the premises should be audible within any other premises between 2300 hrs and 0700 hrs.

In addition to considering noise exposure of customers consideration must be given to bar staff and other employees. Currently the Health and Safety Executive is the enforcement authority but their involvement in this aspect of occupational noise exposure is limited. New allocation regulations may transfer such premises to the local authority. There is an obvious need for a uniform policy to be applied which takes into account the susceptibility of exposed persons to hearing damage. Regardless of the implications of the Health and Safety at Work Act 1974 for this type of entertainment local authorities should ensure that adequate controls are introduced at all events carried out on their premises. It may be necessary to provide basic information to schools and youth clubs in addition to those involved with commercial entertainment activities.

4.2 Live amplified rock/pop music

Much of the foregoing section is as relevant to pop concerts as it is to discotheques. However, particular problems have been experienced with major open-air events. The Greater London Council has produced a document which gives guidance on aspects of safety, health and welfare provision for pop concerts. Many of the issues considered in this excellent document are beyond the scope of this paper but mention is made of the main recommendations in the section dealing with noise. It is suggested that to minimise the potential risk of hearing damage to members of the audience at concerts staged at outdoor premises, the Leq at a distance of 50 metres from loudspeakers should not exceed a level which would give a sound energy immission over the period equivalent to a continuous Sound Level (Leq) of 93 dB(A) for 8 hours. A similar condition is proposed for indoor events except that no concession is made in relation to the separation of the audience from speakers.

To minimise noise, the GLC code infers that sites of outdoor concerts should not be used on more than three days in any year. Furthermore, 15 minute Leq levels from open air concerts should not exceed the ambient Leq for a comparable period, by more than 10 dB(A) between 0700 hrs to 2000 hrs or more than 6 dB(A) between 2000 hrs and 2300 hrs when measured outside the windows of noise sensitive premises. Similar conditions are proposed for indoor events.

As identified earlier in the paper, professional and amateur musicians may suffer permanent hearing damage because of the level at which music is amplified. It is difficult to envisage any pop group performing whilst wearing hearing defenders, but there is no reason why ancillary staff could not be provided with protection. This is of particular importance where local authorities are involved in the direct or indirect provision of this form of entertainment.

4.3 Classical Music

No case has been made for traditional concert halls erecting notices to indicate that 'loud noise can damage hearing!' but local authorities involved in municipal orchestras or youth orchestras should consider the need to measure exposure levels of players and bear in mind the possibility of rearrangement of the orchestra itself.

4.4 Earphones and personal cassette players

The only action available to those concerned with this aspect of noise exposure is the non-alarmist use of publicity identifying the need to limit volume.

4.5 Arcade Games

This noise source has only recently been identified as a cause of concern. Perhaps a condition could be imposed on an amusement arcade limiting sound levels. Certainly more research/investigation seems necessary to determine if this is likely to be a problem in the UK.

4.6 Fireworks

Evidence suggests that the casual misuse of explosive fireworks can not only maim but may have other insidious effects. It supports the argument that such fireworks should not be on sale to the general public on the grounds of safety. It could also further encourage organised firework displays, including municipal events, where noise exposure can be controlled.

4.7 Toys and toy guns

Excessive noise levels from children's playthings seems to call for further research. It is understood that this matter is currently receiving the consideration of trading standards authorities.

4.8 Sports Guns

It is unlikely that many local authorities will be directly involved in the organisation of shooting events. Where they are, it is important to realise that hearing protection is not only necessary for the shooters - other workers required to stand near guns must also be considered.

4.9 Racing Cars

Track marshals and other stewards required to work at motor racing events may need to be provided with hearing protection. Drivers seem more aware of the dangers and may take some protective steps[3].

4.10 Model aircraft and boats

Local authorities are often able to influence the areas from which planes can be flown or boats raced. If clubs are supported by the authority, advice may need to be given to membership on risks associated with engine tuning.

4.11 General

In addition to the specific noise sources identified in the previous paragraphs, other leisure-associated noise sources may be identified in specific premises. For example, when the Noise Advisory Council produced general guidance on recreation noise[2] it made specific reference to swimming baths. The Institute of Hearing

Research[3] review only reports limited data associated with pools but does not identify a particular risk. Where there is doubt the only option is to determine the noise level experienced by the most severely exposed individuals and assess the risk.

Account must also be taken of the disturbance which can be caused by certain leisure activities. A balance must be found between the need for recreation (which may produce noise) and the requirement for the freedom from intrusion caused by entertainment noise. A three-day pop concert will be experienced in different ways by the attenders and the residents of the neighbourhood.

5. CONCLUSIONS

The review of literature carried out by the Institute of Hearing Research[3] has identified a number of issues which may be of particular interest to environmental health workers. This paper has attempted to highlight a few important points but has only skimmed the surface. Those seeking to develop protection strategies in relation to any of these subjects would do well to read all the literature before embarking on educative or enforcement campaigns. It is not unknown for remedial strategies to be ill-considered, resulting in ineffective action or public antagonism. Local authority officers and members will fully realise the value of unimpaired hearing at all stages of life: perhaps some need to consider whether any activity carried out by their organisation could be causing hearing damage.

APPENDIX 1

NOISE LEVELS - PLACES OF PUBLIC ENTERTAINMENT - LEEDS CITY COUNCIL

The ability to control sound levels in places of public entertainment was peculiar to the former Leeds County Borough Council in as much as Section 277 of the Leeds Corporation Consolidation Act 1905 provided that the Corporation "may licence premises for music and dancing subject to conditions".

During the second half of 1972 the Anti-Pollution Sub-Committee of the then Leeds County Borough Council received reports and information from its own Technical Officers and Mr. R.W. Fearn, Principal Lecturer, Leeds Polytechnic, Department of Architecture on which it based its opinion that:

a) the levels of amplified music in places of public entertainment was such that there was a probability of hearing damage occurring to patrons;

b) a legal limit should be set to levels of amplified music to protect the hearing of the public;

c) that this limit should be specified in licences granted under the provisions of Section 277 of the Leeds Corporation Consolidation Act 1905.

The Fire Brigade and Licensing Committee accepted the recommendations of the Anti-Pollution Sub-Committee and the following conditions were included in all licences issued to be effective on or after the 1st January 1974.

"At no time shall the noise level in any part of the premises, measured with a precision sound level meter on a slow setting at a fixed point not less than 2 metres away from any loudspeaker or other source of amplified noise, exceed 96 dB(A)".

"Where live performances take place, the above clause shall apply measured at the nearest point of access to any loudspeaker by members of the public, except that no loudspeaker shall be within 2 metres of that point".

There were several practical reasons why the existing legal limit and the conditions did not enable the Department of Environmental Health to exercise effective control. In addition to the fact that the levels imposed did not appear to be based on any established scientific work there was also the difficult problem of carrying out measurements with a conventional sound level meter without the management of the establishment under consideration being well aware of what was happening and therefore being able to take evasive action. Furthermore, with a maximum sound level as low as 96 dB(A), that level is likely to be exceeded inadverte inadvertently on a number of occasions during the evening, if only for a second on each occasion. One excursion above the legal maximum would have been a "prima facie" offence, which could involve the licence holder in legal proceedings. In practice, Officers were instructed to take action by warning the licence holder only if the measured sound levels:

a) exceeded 96 dB(A) for 10% of the time (L_{10}) for 10% for amplified recorded music;

b) exceeded 96 dB(A) for 20% of the time (L_{20}) for amplified live music.

The correct point to monitor is at ear level. A sound level meter cannot easily be operated under such circumstances. This problem could be overcome by the use of a microphone with an extension lead but in the subdued lighting found in such establishments there is a real risk of accidents occurring to patrons, Officers and equipment. The type of lighting used also makes it difficult to read the scale on the instrument.

In the light of experience gained from its first attempt to control noise in places of public entertainment the Environmental Health & Control Committee of Leeds City

Council decided to reconsider the subject. It was resolved that in principle the Department of Employment's Code of Practice for the Protection of Employees in Occupational Hearing Loss (based on a principle of equivalent continuous energy levels) be applied to places of public entertainment in the City, adjusted for the duration of the business in a 24 hour period. This Code was based on work carried out by Professor W. Burns, University of London and D.W. Robinson, Head of Acoustics Section, National Physical Laboratory who indicated that 90% of the working population would not suffer permanent hearing loss if their daily exposure to noise did not exceed the equivalent of a continuous level of 90 dB(A) for an eight hour period. This is known as 90 dB(A) Leq.

In order to consider, in detail, the form in which a Code of Practice would be drafted a Working Party was set up involving the Appointed Members of the Environmental Health & Control Committee, Officers of the Department, representatives of hoteliers, the Association of Ballrooms, local brewers, village and church halls, Musicians Union, Students Union of the Local University and private clubs.

Although the working party met on a number of occasions it proved difficult to reach a consensus on control. It was finally agreed to await a lead from the Noise Advisory Council and the Department of the Environment. That lead has yet to be given.

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– ENERGY FROM MUNICIPAL WASTES – REFUSE DERIVED FUELS

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INTRODUCTION

The utilization of waste materials as an energy source has been practised on a limited scale and generally in inefficient operations for many years. It has taken the sudden and rapid escalation of world fuel prices to provide motivation for extensive research and development into ways for using these potentially important energy sources more efficiently. Wastes may be utilized directly as fuel or processed to remove non-combustible materials before being burned or, alternatively, processed by pyrolysis or biodegradation into liquid or gaseous fuel. Some 7 types of refuse derived fuel (RDF) are recognised by the American Society for Testing Materials (ASTM)(1). These are:

1. wastes used in as-discarded form
2. wastes processed to coarse particle size with or without Fe separation
3. shredded fuel derived from refuse (municipal solid waste) which has been processed to remove metal, glass and other inorganic materials
4. combustible wastes processed into powder form (95% weight passing 10 mesh (2 mm) screening)
5. combustible wastes densified into the form of pellets, slugs, cubes or briquettes
6. combustible wastes processed into liquid fuel
7. combustible wastes processed into gaseous fuel

This paper concentrates on the production and combustion of shredded or densified (pelletized) RDF derived mainly from domestic (municipal solid waste), commercial and industrial refuse.

WASTE ARISINGS IN GT BRITAIN

Estimates show that some 73 Mte of wastes are discarded annually in Gt. Britain from agriculture, forestry, industrial and commercial operations and in domestic refuse(2). Table 1 shows that these wastes contain an estimated 29 Mte of potentially combustible materials of which about 69% are contained in refuse from industrial, commercial and domestic premises.

DOMESTIC REFUSE

Some 17–18 Mte of refuse are collected annually by local authorities of which about 80% is removed from domestic premises. Potentially combustible and putrescible materials were estimated to account for about 66% of the contents of domestic refuse in 1980(2). However, refuse composition varies widely reflecting changes in living standards over time and from one locality to another. Variations also occur on a seasonal basis. Table 2 illustrates the change in average composition over a 7 year period to 1980.

Cinders which accounted for the bulk of screenings below 20 mm in 1973 have fallen by over 30% while putrescible materials are now discarded in much greater amounts. A 2–3 fold increase in the plastics content largely reflects the growth in packaging from higher consumption of convenience foods and innovations in packaging practices.

INDUSTRIAL AND COMMERCIAL REFUSE

The contents of industrial and commercial refuse reflect the nature and business activity of the producer. Refuse from offices may contain as much as 80% combustible materials compared with only 45% from the distributive trades. In general the combustible content of refuse from industrial sites relates to the size of administrative/office facilities present on the site, the amount and nature of the packaging materials (if any) on purchased materials and the rate of wastage of combustible materials used on-line in production operations. It may range from as little as a few per cent in brick, pottery, glass and cement works to almost 40% in motor vehicle manufacturing and often as high as 90% in some instrument assembly operations.

PREPARATION OF REFUSE DERIVED FUELS

In the UK RDF falls into two principal categories:

i) shredded or "fluff" ie non-densified

Table 1. Estimated waste arisings* in Great Britain in 1981(2)

	Gross weight $t \times 10^{-6}$	Potential combustible Quantity $t \times 10^{-6}$	Distribution of combustibles %
Domestic refuse	18.0	12 (incl vegetable and putrescibles)	41
Commercial refuse	3.8	1.6	6
Industrial refuse	19.0	4.1	14
Industrial process wastes	23.0	2.3	8
Agricultural (surplus straw, plastics only)	8.0	8.0	28
Forestry	1.0	1.0	3
Total all sectors	72.8	29.0	100

* Excludes mining, quarrying, construction site wastes and power station ash

ii) pelletized or briquetted material ie densified

The former ranges from shredded refuse, from which fines may have been removed by screening, to a highly segregated product comprising predominantly paper and plastics. Further processing is needed for densified fuel production.

SHREDDED OR NON-DENSIFIED RDF

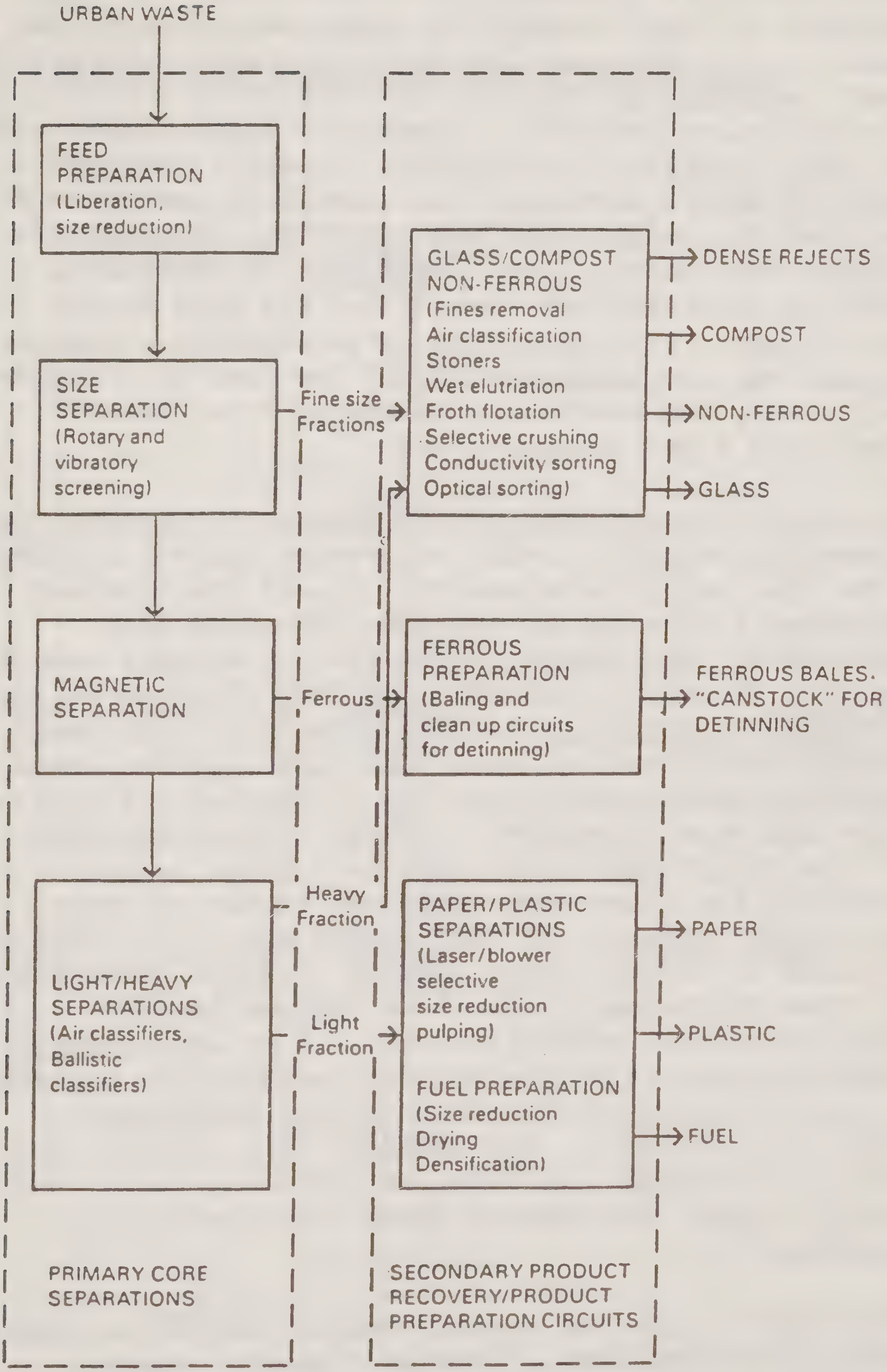
The commercial exploitation of RDF has been pursued widely in the US with varying degrees of success. Some twenty facilities are either in operation or at different stages of commissioning. However various problems have been encountered including, in some cases, a lack of customers for the RDF. Other plants are under construction or in their final contract stages(4).

Systems for the recovery of non-densified RDF from refuse are generally based on designs comprising some combination of size reduction, screening, classification and magnetic separation, as shown in Fig. 1, although the order and numbers in which these units are combined

Table 2. Average composition of UK domestic refuse(3)

	1973	1980 %
Screenings below 20 mm	20	14
Vegetable and putrescible	18	26
Paper	33	29
Metal	9	8
Textiles	3	3
Glass	11	10
Plastics	2	7
Unclassified	4	4
	100	100

Fig. 1. - Refuse Sorting Processes(5)

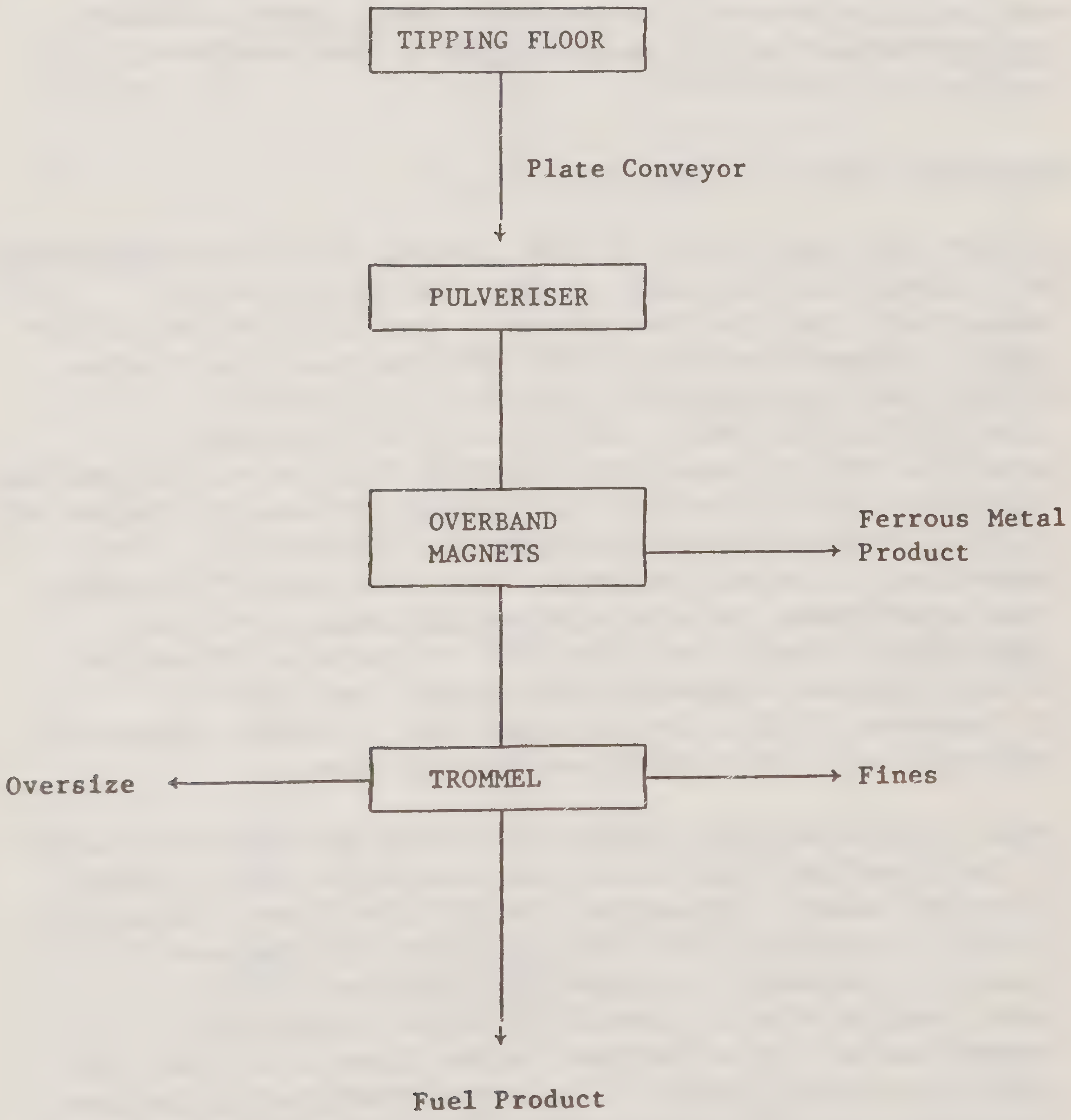

URBAN WASTE
FEED PREPARATION (Liberation, size reduction)
SIZE SEPARATION (Rotary and vibratory screening)
MAGNETIC SEPARATION
LIGHT/HEAVY SEPARATIONS (Air classifiers, Ballistic classifiers)
PRIMARY CORE SEPARATIONS
Fine size Fractions
Ferrous
Heavy Fraction
Light Fraction
GLASS/COMPOST NON-FERROUS (Fines removal Air classification Stoners Wet elutriation Froth flotation Selective crushing Conductivity sorting Optical sorting)
FERROUS PREPARATION (Baling and clean up circuits for detinning)
PAPER/PLASTIC SEPARATIONS (Laser/blower selective size reduction pulping)
FUEL PREPARATION (Size reduction Drying Densification)
SECONDARY PRODUCT RECOVERY/PRODUCT PREPARATION CIRCUITS
DENSE REJECTS
COMPOST
NON-FERROUS
GLASS
FERROUS BALES. "CANSTOCK" FOR DETINNING
PAPER
PLASTIC
FUEL

varies from plant to plant. In general dry shredding of the refuse is preferred but systems such as those developed by Black Clawson and subsequently installed at Hempstead, NY, and Dade County, incorporate hydropulping or wet shredding of the solid waste to form a slurry from which the heavy fraction is removed. After recovery of the light fraction, the moisture content is reduced to about 50% before burning. The commercial operation at Hempstead has experienced both technical and pollution problems which have led to suspension of processing since the early part of 1980(4) but the Dade County plant is said to be operating satisfactorily. However the wet fuel provides only 50% of the feed to the Dade power plant; the balance is recovered from "trash" waste using a dry process route.

In certain circumstances a high degree of upgrading to improve the calorific value and reduce the ash content of the fuel may be unnecessary. One of the simplest approaches to the use of shredded refuse is that developed by IMI. Waste preparation is minimal and after shredding to better than 90% less than 70-80 mm in size and magnetic removal of ferrous material, the product is injected into a moving grate coal-fired furnace where combustion takes place above and on the bed. A similar system has been established on South Humberside where RDF from the Grimsby waste treatment plant is sold to Courtaulds for augmenting coal feed to two of their chain grate boilers. In the Grimsby plant, illustrated in Figure 2, refuse, after removal of large items which may cause blockages, is fed to a Tollemache 72A pulverizer with a capacity of 250 t/8 hr day. Following a magnetic separation the shredded material is screened to remove the ash and fines and then transported directly to the user. The shredded fuel fraction has a net C.V. of around 11.6 MJ/kg and replaces coal, roughly on a 2:1 basis, for process steam and electricity generation(6).

An alternative use for crude, undensified RDF is direct firing to replace part of the coal used in cement manufacture. A process has been developed by Blue

FIG 2. FLOW DIAGRAM FOR GRIMSBY SORTING PLANT



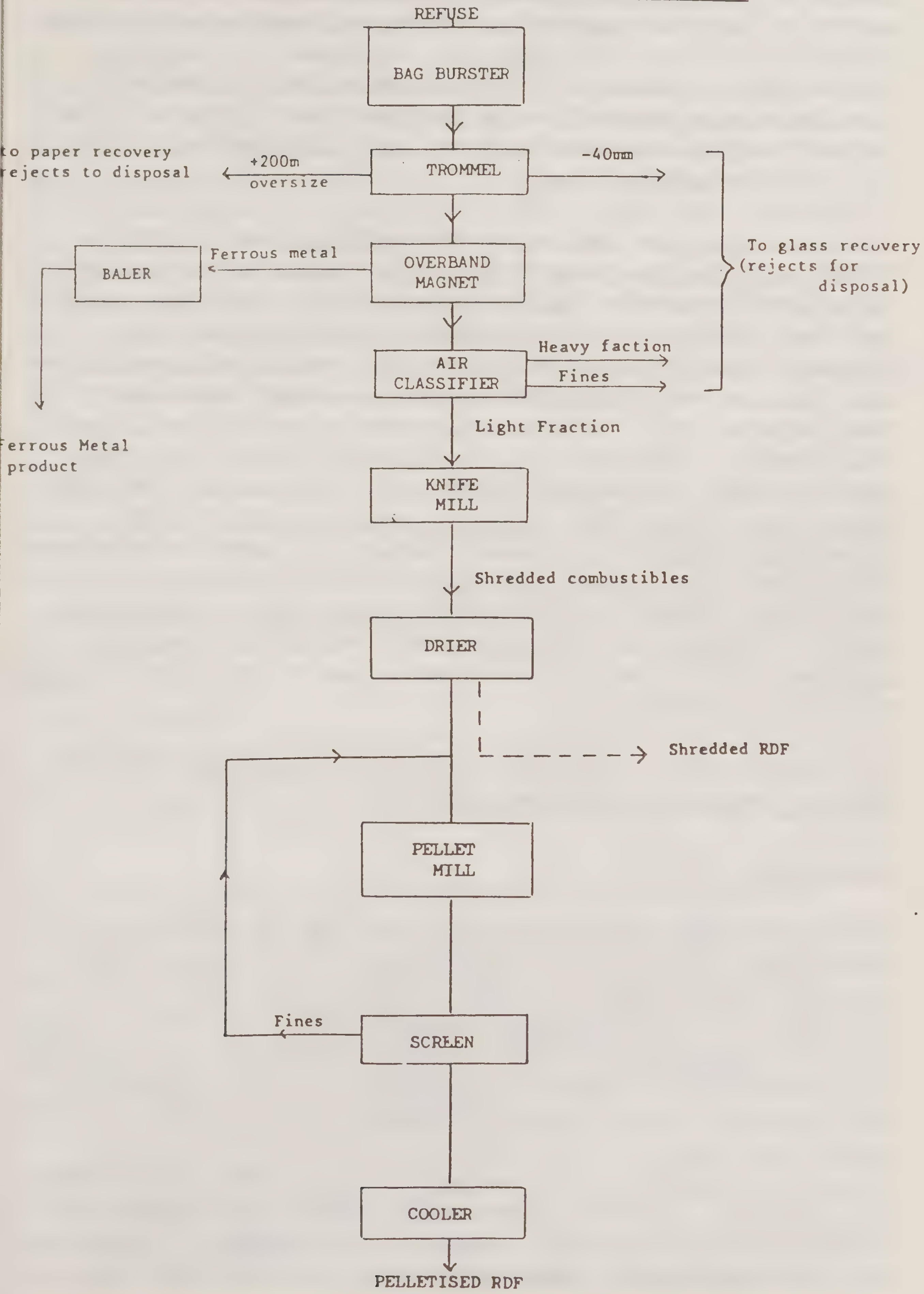
Circle Industries for firing their wet process kilns at Westbury with refuse supplied by Wiltshire County Council. The amount of RDF burned is constrained by the amount of refuse ash which can be absorbed by the cement but the company claim that savings of 12–13% of the primary fuel normally consumed have been achieved(7). Apart from energy savings, the process has significant environmental benefits, allowing the incorporation of ash into the cement clinker while acid gases released during combustion are neutralized by the alkaline mixture in the kiln(8).

DENSIFIED OR PELLETIZED RDF

One of the constraints on the general use of shredded RDF as a substitute for coal is the limited number of commercial installations where it can be burnt satisfactorily. Densification of the RDF improves its handleability and increases its potential for direct substitution for small coal in existing systems. Densified RDF is generally produced from an air classifier light fraction of refuse via further processing stages of milling, drying and pelletizing or briquetting. The technology is mostly based on that developed for animal food production, ie ring die pelletizers. Initial experience showed that with RDF the tonnage throughput is much reduced compared with animal feed due to differences in flow characteristics. However, research has shown ways of minimising this problem.

Three refuse sorting plants are being operated in the UK by local authorities to produce densified RDF at Byker (Tyne and Wear), Doncaster (South Yorks County Council) and at Eastbourne (East Sussex Council). Refuse at Byker is shredded, screened and air classified in a novel design of air classifier which relies on compressed air to establish vortex flow in an inclined rotating conical shell. The light fraction is further upgraded on a PLM screen and then reduced in size prior to pre-densification in a primary pellet mill, following which the product is dried in a rotary cascade drier before final pelleting(9). The current plant has a

FIG. 3. FLOW DIAGRAM FOR RDF RECOVERY AT DONCASTER



design throughput of 30-40 t/h refuse and following modifications to improve performance, has potential for producing up to 9 t/h pellets. Adjacent to the plant is the boiler house of the Newcastle City district heating scheme where the pelletized fuel is burnt in a Vekos fixed grate shell boiler, any surplus fuel being sold for industrial use.

The sorting plant operated at Doncaster was built by Motherwell Bridge Tacol Ltd and is based on technology developed at Warren Spring Laboratory. The flow sheet for the plant, shown in Figure 3, was designed to provide flexibility in processing. Reclaimed products are ferrous metal and RDF; paper recovery has been demonstrated but the glass recovery circuit has proved uneconomic. Recovery of non-ferrous metals and other constituents may be possible at a later date. Primary screening rather than milling, coupled with further screening during air classification, is used to minimize ash, cinder and glass contamination of the fuel product. The light product from the air classifier (a patented design by Motherwell Bridge Tacol and Warren Spring Laboratory(10)) is knife milled prior to pneumatic drying and pelletization.

The Eastbourne plant uses technology developed by the Buhler Company of Switzerland(13).

COMBUSTION OF RDF

It has already been indicated that RDF is heterogenous in nature. Wide variations exist in its composition, particle shape and size distribution and these are reflected in the combustion characteristics. Early work on RDF production in the UK was directed mainly towards the densified or pelletised product on the assumption that pellets, which resemble small coal in size, would avoid the need for investment in special handling or feeding equipment thus making the fuel more attractive to industry. Initial combustion trials gave promising results and industrial interest was aroused. However, as the development work progressed some difficulties were experienced due largely to significant differences between the properties of RDF and coal.

A comparison of the analyses of RDF and coal is shown in Table 3 where it can be seen that the volatile content of RDF is substantially greater than that of coal while the fixed carbon content is very much lower. Also thermogravimetric analysis has shown that the evolution of volatiles during RDF combustion occurs rapidly at a relatively low temperature. Ultimate analyses for RDF show low sulphur and relatively high chlorine and oxygen contents compared with average coals. Depending on the method of production, the ash content of RDF is generally at least twice that of good quality coal.

Table 3. Comparative proximate analysis of RDF and coal

	RDF (Doncaster average)	Typical coal
Moisture %	15.0	6.1
Ash %	11.4	6.5
Fixed carbon %	11.6	53.4
Volatile matter %	64.0	34.0
Calorific value MJ/kg (net)	15.3	27.1

All these factors have significant implications for efficient RDF combustion. For example, provision of combustion air requires detailed attention to ensure overbed combustion of volatiles. Overheating in the fuel bed must be avoided as RDF ash generally has a lower softening temperature than coal ash giving rise to a tendency to clinker formation which can be a serious problem in fixed-grate systems.

Commercially, RDF is a relatively new product and there is a tendency to assume that because of its major paper and plastic content it will burn readily. Thus until recently few data have been available relating to its

Table 4. Comparative data for coal and RDF combustion (11)

Boiler Type	Heat Input MJ h^{-1}	RDF %	Heat Losses, %			Thermal Efficiency %	Particulate Emissions kg h^{-1}	Remarks
			C in Ash	Flue Gas	Radiation			
Fixed Grate	5540	100	0.6	11.2	3.5	84.7	0.58	Pellets
	6300	100	3.2	13.1	29.1	54.6	1.09	Shred
Underfeed Stoker	3160	0	5.6	24.2	3.0	67	0.16	Coal
	1730	50	11.3	24.3	3.0	62	0.29	WDF pellets + coal
	1690	50	16.5	29.2	3.0	52		WDF + coal pellets
	1400	80	10.2	39.2	3.0	48		WDF + coal pellets
Chain Grate	89450	0	3.6	14.2	0.4	82	16.2	Coal
	94240	50	3.0	20.2	0.1	78	79.9)	
	105490	60	3.4	18.1	2.4	76	)	WDF shred
	106710	40	3.6	17.4	1.4	78	47.8)	
Fluidised Bed	1120	100	0.5	16.7	16.8	66	0.94	Shred
Starved Air Incinerator	17400	100	5.4	23.8	3.4	67	3.81	
Fluidised Bed	14800	0	5.0	83.7		84	)	Silage drier
	12390	100	4.3	90.2		90	)	
Fixed Grate	14500	100	2.5	25.0	3.0	69	2.36	
Shell Boiler	1570	100	2	27	<1	58		As commissioned
	1570	100	2	23	<1	71	0.29	Boiler optimised
	2010	100	2	22	<1	81		Higher feed rate

combustion characteristics. Combustion trials on various types of industrial boilers are being pursued by Warren Spring Laboratory on behalf of the Energy Technology Support Unit. Results from some of these trials are summarised in Table 4. RDF has been burnt in several types of grate and in fluid-bed combustors with varying degrees of success. As yet it has not been possible to define optimal conditions for RDF combustion. None of the pellet combustion trials have been of long duration as only now is the position being reached where significant tonnages of RDF pellets are being produced consistently. Nevertheless preliminary results are very encouraging. Thermal efficiencies approaching those obtained with coal have been achieved, although some derating of boilers may be necessary. Improved ash handling equipment is required however to cope with the higher quantities of ash from RDF combustion.

Some of the difficulties can be minimised by modification of the RDF production process. At the Byker plant, the introduction of the PLM screen has resulted in a much lower ash content in the fuel. Other modifications are possible; for example, the use of additives during pelletization to change the ash fusion characteristics or provide harder pellets thus minimising dust problems.

Economics of RDF usage on a commercial scale must take account of the efficiency of its combustion, the cost of additional emission control measures and of residue disposal as well as its intrinsic energy content. As yet there are no agreed specifications which take account of combustion performance of RDF or enable its combustion efficiency to be related to the C.V. and physical and chemical characteristics of the unburnt material. Further extended trials are necessary to obtain a clear definition of any difficulties arising during RDF combustion so that causes can be identified and ways of overcoming them can be demonstrated.

EMISSIONS DURING COMBUSTION

The possibility of hazardous emissions resulting from

Table 5. Emissions from the Combustion of RDF (11)

Boiler Type	RDF	Particulate Emission	Emission Limit	Sulphur Emission		Chloride Emission		Lead Emission		Cadmium Emission		Remarks
	%	$kg\ h^{-1}$	$kg\ h^{-1}$	$kg\ h^{-1}$	$mg\ MJ^{-1}$	$kg\ h^{-1}$	$mg\ MJ^{-1}$	$g\ h^{-1}$	$mg\ MJ^{-1}$	$kg\ h^{-1}$	$mg\ MJ^{-1}$	
Fixed Grate	100	0.58		0.48	86	1.89	340	-	-	-	-	Pellets
	100	1.09		0.38	48	0.04	6	-	-	-	-	Shred
Underfeed Stoker	0	0.16)	2.4	0.33	190	-	-	-	-	-	-	
	50	0.29)		0.33	190	0.14	85	-	-	-	-	
	75	0.24)		0.28	200	0.30	210	-	-	-	-	
Chain Grate	0	16.2)	18.0	57.9	650	8.3	93	34	0.4	-	-	
	50	79.9)		41.2	440	16.8	180	410	4.3	-	-	Shred
	40	47.8)		43	400	5.6	52	280	2.7	-	-	Shred
Fluidised Bed	100	0.94	1.1	0.21	172	0.67	550	12	10	0.5	0.4	
Starved Air Incinerator	100	3.81	4.2	1.71	98	4.86	280	485	28	8	4.5	
Fluidised Bed	0	(110)	-	7.69	530	0.27	19	26	2	-	-	Silage drier = ( )
	100	(264)	-	2.14	173	0.52	42	130	10	-	-	Particles at furnace outlet
Fixed Grate	100	2.36	13.3	0.75	52	2.60	180	39	23	1	0.7	Pellets

combustion of refuse derived fuels has been of concern to those working in this field and extensive results are reported in the literature. Unfortunately, there is little consistency in the methods used or in the reporting and in many instances the results are contradictory. One of the main problems is that combustion trials are still at the experimental stage and generally conditions have not been adequately controlled or optimised for RDF combustion. In some instances, the introduction of RDF into existing coal burning facilities and the subsequent monitoring has shown deficiencies in the control of coal burning alone. Consequently base line data for comparison purposes have to be established.

Some emission data for coal, coal/RDF mixtures and RDF alone are given in Table 5. The main points to note are that sulphur emissions are lower with RDF whereas chloride and heavy metal emissions are generally higher than in coal combustion. It is generally assumed that the higher chloride emissions result from the PVC content of the RDF but refuse does have a significant chloride content apart from PVC. Ways of minimising the chloride emission, such as the addition of a suitable reagent to retain chloride in the ash or alternatively a possible extra sorting stage to remove PVC during refuse processing, have been postulated. Similarly, heavy metal emissions from waste combustion have been investigated(13) and it has been concluded that the problem can be minimised by more rigorous attention to the separation of the light combustible fraction during RDF production. Concern has also been expressed over the possible presence of trace quantities of potentially toxic hydrocarbon or chlorinated compounds, such as dioxin, in the emissions from RDF combustion. This concern applies equally to combustion of coal and other fuels and the subject is being actively researched. At Warren Spring Laboratory methods for measuring organic emissions have been developed and data are being collected and analysed but it is too early for positive conclusions to be drawn. Generally organic emissions relate to the efficiency of combustion and any problems are expected to be minimized as greater experience and expertise in RDF combustion is developed.

ECONOMICS OF RDF USE

Although there are ample references in the literature to predicted or estimated costs for RDF production and combustion few, if any, of the systems available have been operating continuously and consistently for sufficiently long periods for reliable cost data to have been obtained. In practice the capital and operating costs for RDF production are location dependent. Land, building costs, labour rates and local regulations all affect the overall economics and the operating organisation. The overall viability must be dependent also on the cost of alternative disposal options. In a competitive situation, it is the market for the fuel that will dictate the technology and the type of RDF to be produced. Its market price however must relate to other fuels and take account of differences in calorific values and combustion efficiencies.

The recovery of RDF in a form which enables it to be burned in existing furnace systems and with minimal additional investment by the consumer has been an important objective of RDF producers. Densified or pelletized RDF is relatively costly to produce but, in most instances, can be used in existing coal storage and handling facilities whereas the less costly shredded form will incur higher transport and handling charges. These factors must be reflected in the price of the fuel.

Following monitoring trials of shredded RDF at a UK industrial establishment an economic assessment showed net savings of the order of £180,000 annually to the consumer. The study also established that investment by the user for additional plant and equipment, its installation, trials and commissioning could be recovered within a 30 month period on the basis of an RDF supply having a net C.V. of about 11 MJ/kg and costing £12.50/t (non-densified). It was evident from trial data however that savings on fuel costs were highly sensitive to the C.V. of the RDF supplied and also that it was essential from the user's position for the purchase contract to be sufficiently flexible to permit price adjustments in line with any change in quality.

Pelletized RDF can, in principle, be used as a partial replacement for coal in a range of designs for coal-fired boilers. A recent study commissioned by the Energy Technical Support Unit in the W. Midlands to establish the likely costs and benefits to users converting to RDF showed that at plant sizes above 25,000 lb/hr of steam, payback times of around 2 years can be anticipated on the basis of RDF costing £22/te (£1.42/GJ) replacing around 25% of the energy normally provided by coal or gas costing £57/te (£2.3/GJ) or £0.27/therm (£2.85/GJ) respectively(14).

CONCLUSIONS

Refuse derived fuel is now established as a viable alternative industrial fuel. There remain question marks over some aspects of RDF combustion, particularly regarding acceptable emission levels. Further long term trials are required in order to define possible problems, particularly if more stringent legislation should be introduced, but there is no shortage of potential solutions. As more is learnt on the combustion side information will be fed back to the production system where modifications can be made to improve fuel product specifications. Data collection on commercial combustion systems coupled with laboratory research will lead to optimisation of combustion conditions.

Current indications are that RDF can be produced and used industrially with advantages to both waste disposal authorities in the saving of disposal costs and to the fuel user through provision of a low cost alternative fuel.

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SCARBOROUGH

– ENERGY FROM MUNICIPAL WASTES –
METHANE FROM WASTE

– By –

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INTRODUCTION

This presentation concerns the generation, recovery and use of gases which are formed by the biological degradation of the organic components of waste.

Under the 1974 Control of Pollution Act some 100 million tonnes of domestic, commercial and industrial wastes are disposed of annually with by far the greatest proportion going to landfill sites for controlled tipping.

Once in place in the landfill site, biological processes occur which consume any residual entrained oxygen as a precursor to a more stable degradation or methanogenesis. Under steady state conditions the decay process produces a landfill gas which consists of 60% methane and 40% carbon dioxide.

If left undisturbed this gas escapes through the site surface, contributing to odour nuisance and presenting a potential safety hazard. If, as will be shown later, the gas is collected by some extraction technique then a useful source of energy is produced which can be profitably utilised.

DOMESTIC WASTE

The greatest concentrations of biodegradable materials are to be found in domestic waste (household refuse). This accounts for 1/4 of the annual disposals under the Act.

Attempts have been made to recover materials and energy from waste, but as can be seen from the disposal routes, landfill is still the predominant and cheapest form of disposal. Waste incineration gained a certain popularity in the early 1970s, particularly as energy prices escalated between 1972 and 1974. With few exceptions, however, incineration remains a means of reducing bulk with little or no heat recovery. Mechanical problems, corrosion and variability of supply have typically been the cause of high running costs and limited on-stream

WASTE FROM SOURCE TO SITE

TOTAL ANNUAL DISPOSALS OF
DOMESTIC, COMMERCIAL AND INDUSTRIAL WASTES:

100 MILLION TONNES

DISPOSALS OF DOMESTIC WASTE:

25 MILLION TONNES

→ < 1% MATERIALS RECLAMATION

→ 10% INCINERATION

→ 90% LANDFILL

PRETREATMENT (IF ANY) AT TRANSFER STATION:

- COMPACTION
- SHREDDING/PULVERIZING
- BALING

TYPES OF LANDFILL SITE:

- CLASSICAL BOWL - CLAYPIT OR QUARRY
- VALLEY OR HILLSIDE TIP
- MOUNDED LANDFILL
- LANDFORMING

availability.

Pilot schemes at Byker (Tyne and Wear) and Doncaster, in the public sector, and at Eastbourne in the private sector, have developed the technology and equipment for sorting waste into its principal components for materials reclamation. High capital cost and low market realisations for the main products:

ferrous and non-ferrous metals,
glass,
refuse (waste) derived fuels,

have deterred the extensive introduction of these facilities.

Most pretreatment of waste is consequently limited to processes for reduction in bulk prior to landfilling. This generally applies for larger conurbations where household collections are delivered to central transfer stations. Here the waste is treated (densified) and loaded onto the road, rail or waterway system for containerised transit to the landfill. Notable examples include the GLC/London Brick rail scheme from Hendon to Bedfordshire, the GMC rail scheme to Appley Bridge, near Wigan, each handling over 1000 tonnes of waste per day. A further half million tonnes of waste is shipped annually by barge on the Thames for disposal to riverside sites downstream.

LANDFILL SITES

Disposal sites can be separated into three or four main categories by topography and land use, since local authorities combine waste disposal with land reclamation wherever possible. In areas with a history of minerals extraction, the worked-out claypit or quarry lends itself to a combined disposal and land recovery programme. Elsewhere the re-contouring of the natural landscape is undertaken by valley filling, hillside tipping or mounding. These techniques of landforming find a natural extension in coastal and estuary areas, where tipping is exploited as a means of winning back land from the sea.

THE STRUCTURE OF DISPOSAL INDUSTRY

It is worthwhile examining how the structure of the industry has evolved from the controls of legislation and the ownership and use of the land.

In England the local authority re-organisation of 1974 placed responsibility for waste disposal, site control and site licensing on the County Councils. Hitherto each District had dealt separately with its wastes, as is still the case in Scotland and Wales. This centralis-

COLLECTION AND DISPOSAL

	ENGLAND	WALES AND SCOTLAND
COLLECTION	BOROUGH OR DISTRICT COUNCILS	DISTRICT COUNCILS
DISPOSAL	COUNTY COUNCIL	DISTRICT COUNCIL
CONTROL AND LICENSING	COUNTY COUNCIL	DISTRICT COUNCIL

SITE OPERATION

	OPERATOR	OWNERSHIP
PUBLIC SECTOR	COUNCIL	FREEHOLD LEASEHOLD LICENCE
PRIVATE SECTOR	WASTE DISPOSAL CONTRACTOR	USUALLY LEASEHOLD OR LICENCE
MINERAL EXTRACTOR	EXTRACTOR OR CONTRACTOR	FREEHOLD OR LICENCE.

ation of responsibility and control has resulted in a major transformation for disposal. Most Counties have reduced the number of sites within their boundaries from several score to often ten or less. Local tips have disappeared and been replaced by high tonnage input landfill sites often accepting a blend of wastes. As local politics vary, so too does the waste disposal plan, with some counties endeavouring to secure freehold ownership and public sector operation, whilst others seek to license airspace and contract-out the filling.

The value of airspace for disposal has been recognised by the major mineral extractors throughout the UK. With transport contributing a major cost to disposal, the claypit and the quarry become valuable assets when in close proximity to the populated areas. It is common-place to find a waste disposal offshoot as subsidiary to the large extractors. This represents a remunerative land reclamation activity for many such Companies. Since many extractors also process their materials on site, requiring energy as heat or electrical power, the recovery of landfill gas becomes a further attractive and profitable activity for industries such as cement and brickmaking.

To the resourceful landowner the opportunity now exists for three phases of profit-taking as minerals are quarried for sale, land is reclaimed by landfilling with waste and the gases from landfill are tapped as an energy source.

The independent waste disposal contractor operates between the major disposal authorities and the large private landowners. Usually charging a tonnage rate to the authority, the contractor operates on a leasehold or licence from the landowner. Some interesting legal problems may well arise over ownership of landfill gas when it ceases to be a nuisance and becomes a valuable asset with profit potential.

GAS PRODUCTION

The trend towards high input rates, generally to deeper and better covered sites, coupled with modern tipping techniques to achieve better use of airspace by compaction, has created conditions which favour methane production.

The changing lifestyle of society over the past 50 years has been reflected by variation in the waste it produces. The volume of disposable packaging that finds its way to the bin has increased dramatically. Analyses of wastes taken from Manchester (1930) and London (1979) indicate the extent of this change.

The dry weight analysis of refuse in the 80s indicates the presence of 60 to 65% of organic biodegradables, present as carbohydrates, lipids and protein.

ANALYSIS OF SOLID WASTES

	MANCHESTER 1930	MANCHESTER 1959	LONDON 1979
VEGETABLE AND PUTRESCIBLE	24.3	17.2	23.0
PAPER AND CARD	12.5	19.8	37.3
TEXTILES	1.8	2.8	3.5
CINDERS	14.5	12.1	-
METALS	4.2	7.3	7.2
GLASS	3.0	6.5	12
DUST AND FINES	35.5	25.5	6.3
PLASTICS	-	-	3.8
UNCLASSIFIED	4.2	8.8	6.9
ANNUAL TONNAGE (MILLION TONNES)	-	1.2	3.0

These organic materials are broken down by acid-forming bacteria into sugar, glycerol, long chain and amino acids. Further degradation by bacteria produces straight and branch chain fatty acids in the liquid phase, whilst carbon dioxide and hydrogen gases are emitted.

The fatty acids feed methane-forming bacteria to produce acetates with more by-product CO_2 and H_2 and ultimately a gas mixture of methane and CO_2 in stable equilibrium.

TYPICAL DRY WEIGHT ANALYSIS

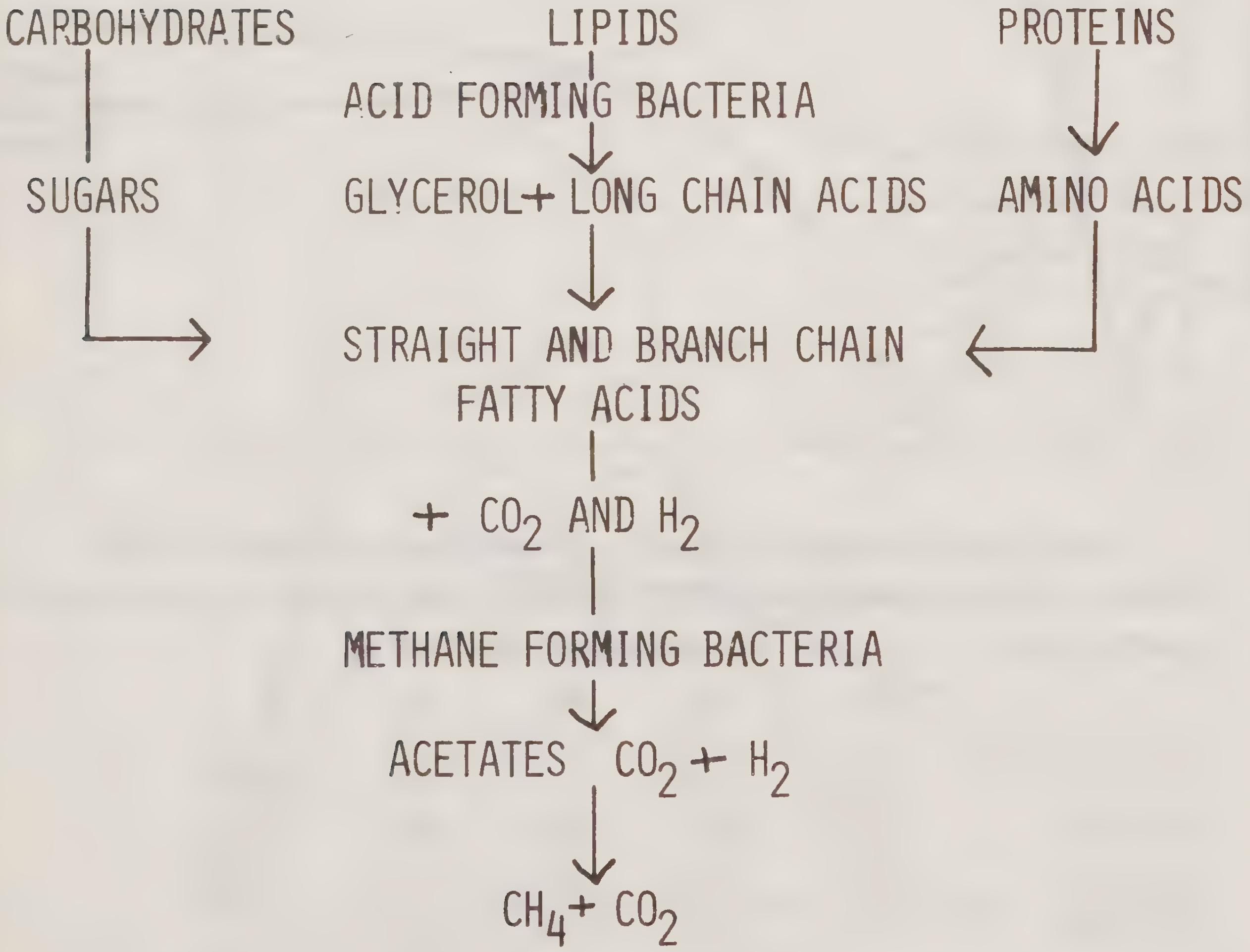
CARBOHYDRATES (CELLULOSE, SUGAR, STARCH) : 55 TO 60%

LIPIDS : 5%

PROTEIN : 2.5%

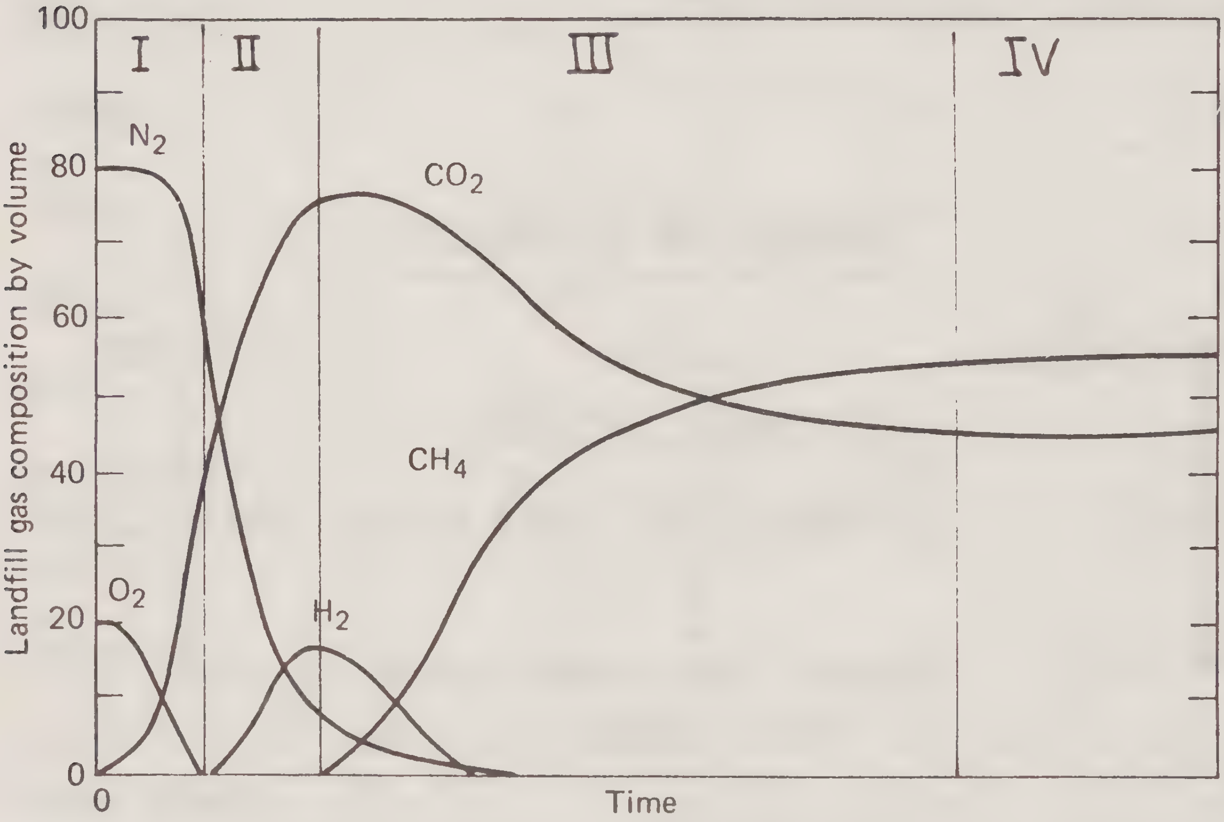
ASH, METAL, GLASS AND PLASTICS : 30 TO 35%

DEGRADATION MECHANISMS



These biodegradation reactions proceed at varying speeds and may be greatly accelerated by the presence of water, or buffered by a reduction of alkalinity from excessive acetate production. Ideally a pH of 6 to 7 favours methanogenesis.

The transition stages of gas formation in landfills have been researched and described by American workers in the mid 1970s.



Landfill gas composition transition. (Cheremisinoff and Morresi 1976)

RESULTS FROM UK LANDFILL (APPLEY BRIDGE), WASTE PLACED APRIL-JUNE 83

SAMPLE DATE	GAS ANALYSIS % V/V				
	CH_4	CO_2	O_2	N_2	H_2
12.10.83	24.1	63.3	TR	0.3	12.3
21.10.83	29.9	62.7	TR	TR	7.4
11.11.83	37.5	53.7	0.1	1.7	7.0
18.11.83	33.4	56.1	TR	0.4	10.1
2.12.83	35.6	54.2	TR	0.3	9.9
14.1.84	53.7	44.2	0.6	1.5	TR
5.2.84	56.2	43.8	TR	0	1.7

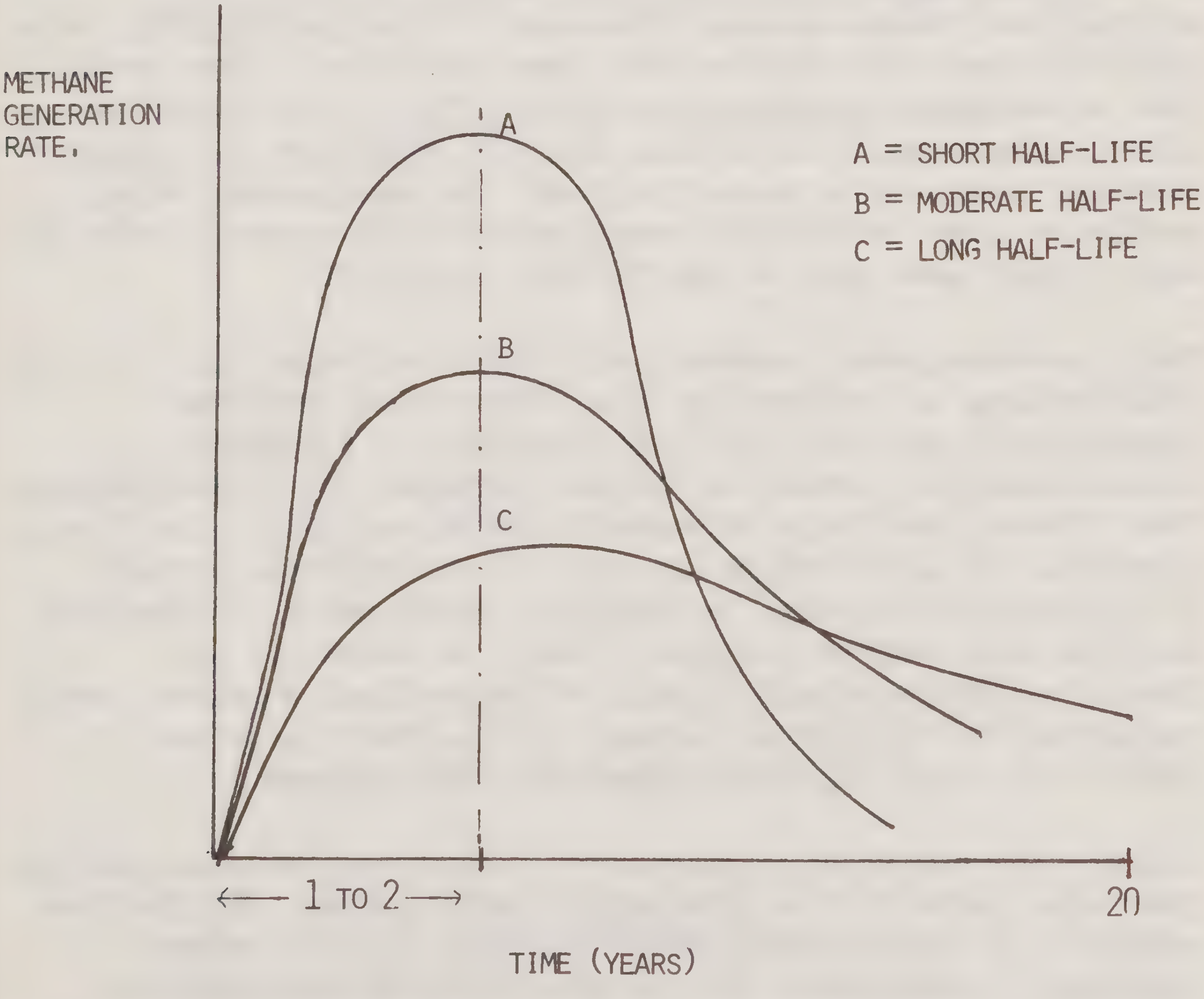
Four reaction steps have been described.

In Stage 1, the processes are aerobic, whilst entrained oxygen is consumed, producing carbon dioxide which in turn expels nitrogen from the intercellular voids.

In Stage 2, non-methanogenic anaerobic decomposition takes place with acid-forming bacteria, producing significant amounts of CO_2 and hydrogen.

Stage 3 is methanogenic but not steady state; methane appears and the CO_2 dioxide bloom is reduced.

In Stage 4, the final stage, methane-forming bacteria have reached a 'steady-state' with reactions that may persist for a number of years depending on site conditions.



GENERATION OF GAS FROM UNIT MASS OF REFUSE

The data presented shows analyses of gases sampled from refuse placed between April and June 1983 at a depth of 6 metres. This illustrates the high initial concentrations of CO_2 and H_2 with a gradual build-up of methane, somewhat enhanced from lower layers of refuse. Under UK conditions, the time to reach steady-state methanogenesis is between 6 and 18 months.

A unit mass of refuse will progress through the transitory stages of gas production and in 1-2 years after placement it will yield gas at a maximum generation rate. Out of all the factors which influence gas production, the concentration of moisture in the waste can be selected as the most predominant rate-controlling function.

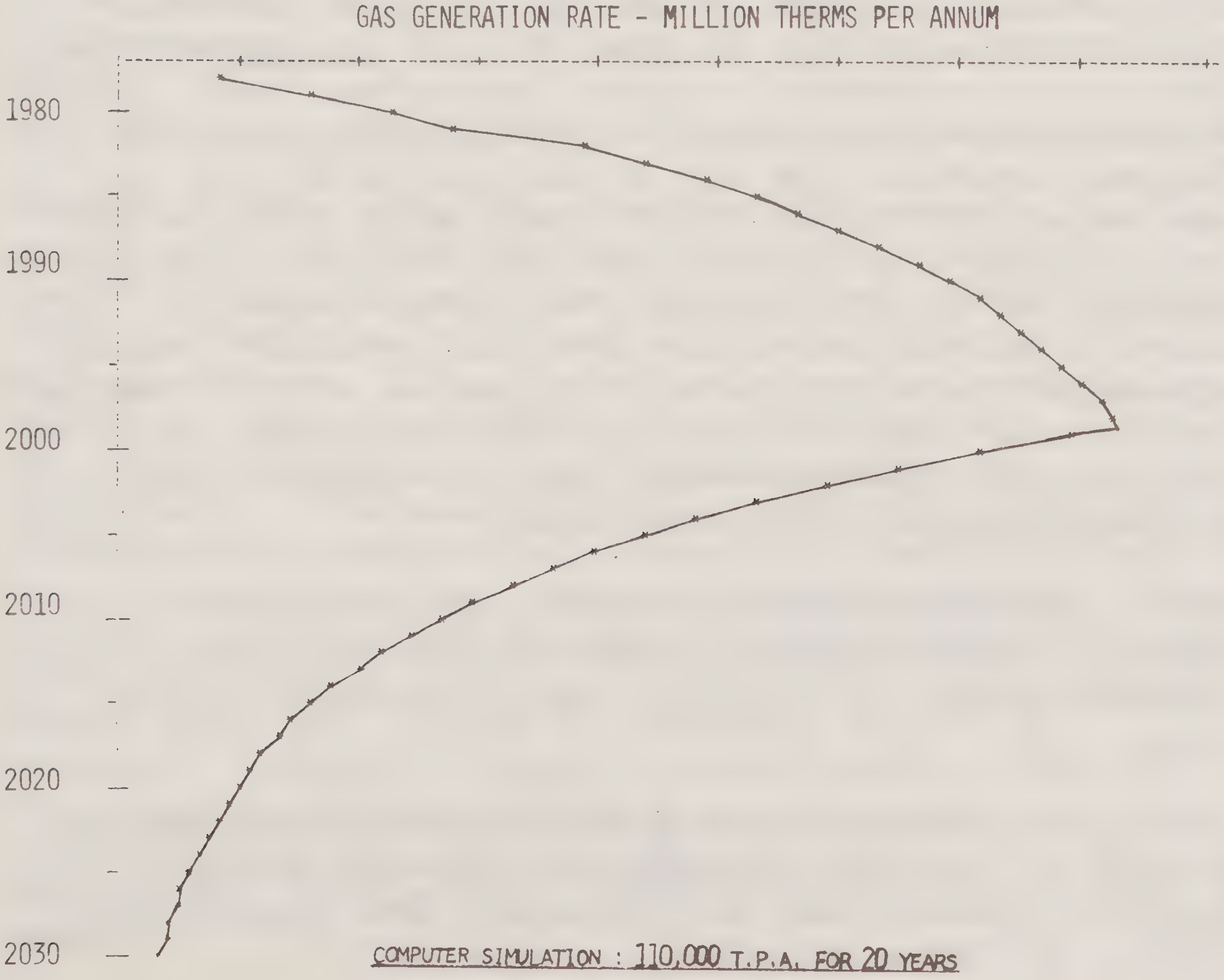
If the degradation process is represented by an exponential decay curve, the plot of gas generation rate against time will follow the form depicted. The decay can be assigned a value for half-life. So a reaction with a short half-life time will be typified by a high initial peak and a rapid tail-off in generation rate, whilst a long half-life reaction will conversely have a much lower peak but a far flatter tail-off.

Many workers have proposed different methods for calculating or estimating the theoretical maximum quantity of gas that will be produced. A simple stoichiometric method is to be favoured for illustration. The further analysis of modern waste has indicated the presence of some 25% by weight of convertible carbon. If this were to react to produce equal molar volumes of methane and carbon dioxide, then one tonne of dry domestic refuse should yield a theoretical maximum gas potential of 82 therms (about 8 GJ), that is about 460 m3 of landfill gas containing 50% methane.

Using this maximum production a value can be assigned to the area beneath the generation rate curve. By further assuming a first order rate equation for the decay process, an estimate of the half-life period can be established. This may vary from 2 to 4 years on wet or flooded sites in the UK or Western Europe, to typically 15 to 20 years on the Western seaboard of the US where rainfall is low.

NCB (CP) has used this data to build a computer simulation of gas generation using half-life as one of the determining criteria and assumptions have been made about the time to reach peak generation rate. The model can be used for predictive exercises with forecast tipping rates or it can be coupled with on-site measurements of gas generation from completed or partially completed landfills. As the knowledge of behaviour of a number of sites under varying conditions increases, so factors can be applied to downrate the estimates from the theoretical generation rate (assuming

PLOT OF GAS GENERATION RATE V TIME FOR A HALF LIFE OF DECAY OF 7 YEARS



COMPUTER SIMULATION : 110,000 T.P.A. FOR 20 YEARS total conversion) to the 'most likely' or attainable rate with an estimated partial conversion.

LANDFILL GAS AND LEACHATE

The gas produced in the modern high density, high input landfill, will ultimately escape to atmosphere. Environmental pressures have dictated the use of nightly cover to reduce fly and vermin nuisance. Landfills will typically employ a bench tipping technique, working in 2 metre layers advancing across the site; or in a confined cell pattern, building-up layer upon layer, each about 300 mm thick to produce an 'onion skin' effect.

The effect of layering, by either method, together with the use of heavy compaction plant and intermediate, generally impervious cover, brings about a marked difference in relative permeability between lateral and vertical migration of gases through in situ wastes.

As the current practice is to cap and often dome the finished landfill with one or more metres of clay to keep water out and gas in, it comes as no surprise that the first signs of landfill gas are often found at the edges of the site or outside the site perimeter. Landfill gas has been known to travel laterally through permeable strata for distances in excess of 1000 metres. The fissured chalk of Kent and the Essex sands and gravels have presented waste disposal engineers with difficult problems in recent times.

Whilst tipping is active, however, gas emissions through the surface will predominate as this will normally present the line of least resistance to gas flow.

The gas produced by these biodegradation mechanisms can be seen to represent considerable nuisance value. Broadly, problems can be categorised into hazards to safety, and odour nuisance.

The flammable or explosion risk is intensified wherever gas can collect in enclosures. This may be in culverts, pipes or manholes on the landfill; or in basements, service ducts or drains and even ground floor rooms of houses beyond the site boundary. In rare cases these problems are compounded by the construction of buildings, without adequate knowledge or precautions, on completed landfills.

A more obvious but less hazardous nuisance is the strong odour that becomes wind-borne from surface gas emissions. During the waste decay process a range of volatile fatty acids are formed as partial breakdown products. Traces of these acids in vapour phase become entrained in the escaping gases, giving them a characteristic and unpleasant smell. Problems of odour had become so great on one GLC site in 1978 that NCB (CP) were called in to assess the practicality of capturing and flaring the emissions to destroy the smell. This was the Company's first involvement with landfill gas, after many years of experience in coke oven gas and colliery methane utilisation, and led eventually to the formation of the NCB/GLC joint venture at Aveley to extract and sell the gas which for so long had been troubling local residents.

Reference has already been made to the necessity for moisture in the fill for gas production, and the reactions take place in the liquid phase. This liquid, known as leachate, can cause additional problems for site operators. Typical samples taken from a highly saturated 180 acre landfill in the West Country illustrate the range of leachate properties that may be encountered. The samples showing high BOD, ammoniacal nitrogen and volatile fatty acids have been collected from areas in the early stages of methanogenesis. Elsewhere on the site the decay reactions have proceeded rapidly through to completion and the groundwaters have been diluted by continued ingress of rainfall, yielding a highly polished sample. The site in question appeared to be a good containment area and not subject to any general water movement across its boundaries. As such this presents no current nuisance value.

LEACHATE ANALYSIS

SAMPLES	1	2	7	12
PH	6.6	6.6	6.8	5.7
CL^-	1380	1060	384	2450
BOD	10400	12000	10	36000
N	493	356	154	596
FATTY ACIDS				
ACETIC	6267	5609	2	21068
PROPIONIC	3536	2490	0.7	6768
ISO-BUTYRIC	415	216	0.3	7.34
BUTYRIC	2591	1039	0.4	11856
ISOVALERIC	502	300	0.2	818
VALERIC	1248	519	0.1	3077
ISO-HEXANOIC	27.6	10	0.1	58.1.
HEXANOIC	1273	283	0.1	3850

If there is general water movement or good drainage from the site, then water pollution problems can rapidly arise. This may lead to contamination of underground water courses or aquifers. Hydrogeological studies play a great part in the selection of sites suitable for landfilling and the Water Authority works closely with the planners. Whilst BOD and VFA's will be reduced with time, nitrogenous compounds are not and the long-term effects of these need further study.

Since 1978 and the initial involvement at Aveley, NCB (CP) has added to its broad range of know-how of gas management techniques. Services now offered by NCB (CP) include:

- Detection and control of migration, with projects undertaken for County Councils and the private sector.
- The removal, by continuous pumping, of gases generated from a site reclaimed for development. The 60 acre Garden Festival '84 site at Liverpool has 30 gas wells

LANDFILL GAS SERVICES UNDERTAKEN BY N.C.B.

GAS MIGRATION - DETECTION AND CONTROL

GAS REMOVAL - LAND RECLAMATION AND RE-USE

GAS RECOVERY - COMMERCIAL SCALE RECOVERY AND UTILISATION

FORMS OF PARTICIPATION

CONSULTANT/CONTRACTOR

JOINT VENTURE PARTNERSHIP

ROYALTY BASED LICENSEE

and 3000 metres of collection pipes to a pumping station, removing 1800 m^3/h of gas containing 25% methane. Here the objective had been to aerate the topsoil and subsoil to create conditions conducive to good plant growth. An excess of methane around the root systems causes rapid die-back.

- Recovery of gas for commercial utilisation as a fuel or energy source. The Aveley venture, commissioned in April 1983, represents the biggest scheme of its type in Western Europe.

The form of participation adopted by the Company depends upon the client's requirements, the commercial opportunity and the availability of finance. NCB (CP) have worked as Consultant and main Contractor, and have entered into joint venture partnerships. Royal licences would also be considered.

RECOVERY OF GAS FOR COMMERCIAL USE

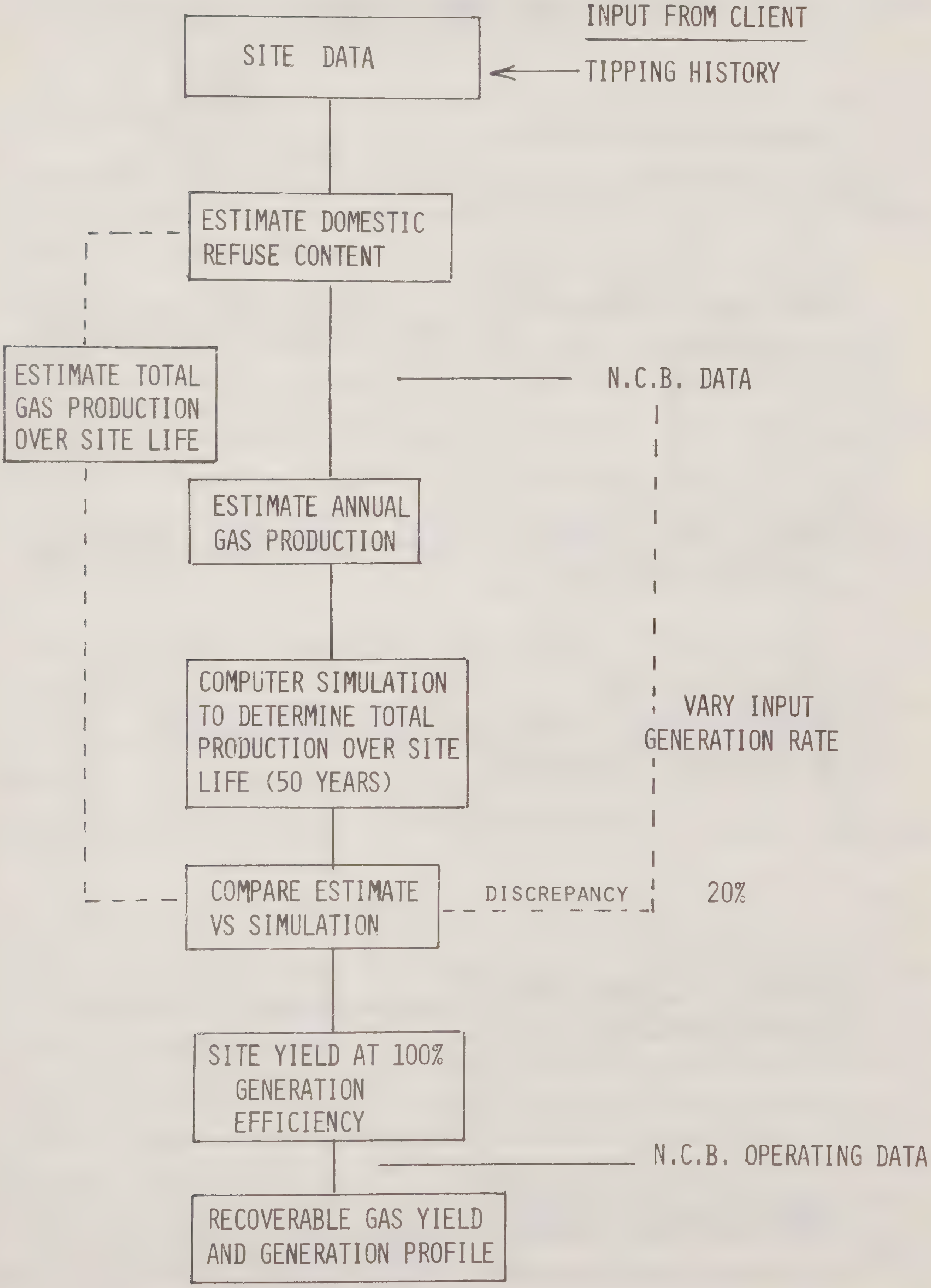
Concentrating on the recovery of gas for a commercial end use, NCB (CP) feels strongly that the whole approach to site investigation, testing and exploitation should be market driven.

As an initial step, a desk study would be undertaken to establish the theoretical and the 'most likely' potential from a landfill. This may be accompanied by simple site tests using a barhole probe and portable monitoring equipment to verify the presence of gas.

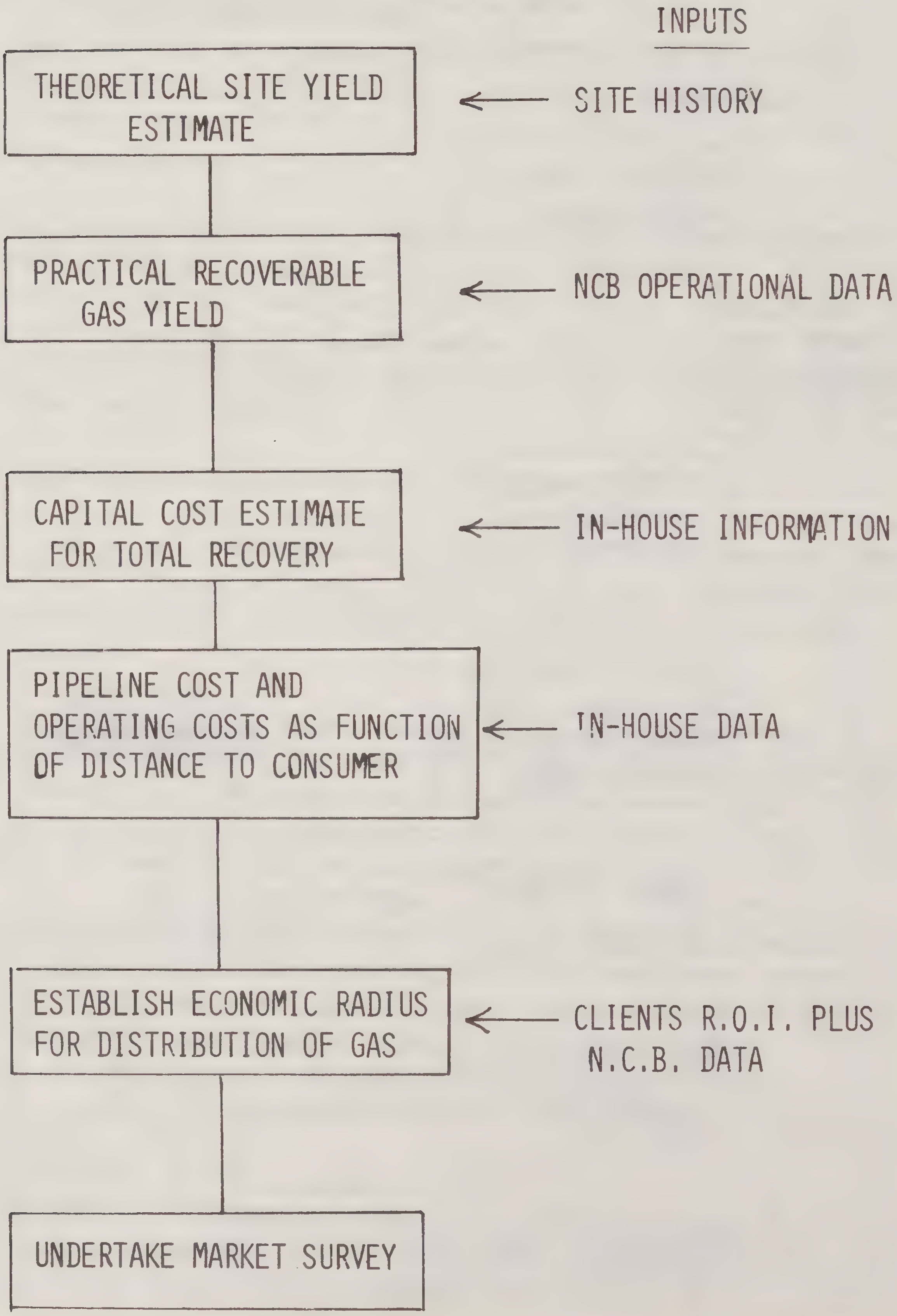
With the theoretical and practical gas yield estimates to hand, cost can be determined for the recovery system and associated on-site expenditure. When combined with pipelining and compression costs, which vary with distance to the user, proceeds and financial return criteria enable an economic radius to be established for a given sales volume.

This concept of economic radius can then be used to define the boundaries for a detailed 'on-the-ground' examination of potential outlets.

ESTIMATION OF LANDFILL SITE GAS YIELD


INPUT FROM CLIENT
SITE DATA
TIPPING HISTORY
ESTIMATE DOMESTIC REFUSE CONTENT
ESTIMATE TOTAL GAS PRODUCTION OVER SITE LIFE
N.C.B. DATA
ESTIMATE ANNUAL GAS PRODUCTION
COMPUTER SIMULATION TO DETERMINE TOTAL PRODUCTION OVER SITE LIFE (50 YEARS)
VARY INPUT GENERATION RATE
COMPARE ESTIMATE VS SIMULATION
DISCREPANCY
20%
SITE YIELD AT 100% GENERATION EFFICIENCY
N.C.B. OPERATING DATA
RECOVERABLE GAS YIELD AND GENERATION PROFILE

OUTLINE APPROACH TO SITE EVALUATION AND MARKET SURVEY


INPUTS
THEORETICAL SITE YIELD ESTIMATE
SITE HISTORY
PRACTICAL RECOVERABLE GAS YIELD
NCB OPERATIONAL DATA
CAPITAL COST ESTIMATE FOR TOTAL RECOVERY
IN-HOUSE INFORMATION
PIPELINE COST AND OPERATING COSTS AS FUNCTION OF DISTANCE TO CONSUMER
IN-HOUSE DATA
ESTABLISH ECONOMIC RADIUS FOR DISTRIBUTION OF GAS
CLIENTS R.O.I. PLUS N.C.B. DATA
UNDERTAKE MARKET SURVEY

NCB (CP) would advocate that site testing and proving are only justified once a market outlet has been identified and after an initial approach has been made to establish the acceptability of the fuel and compatibility of the supply and demand patterns.

SITE EVALUATION

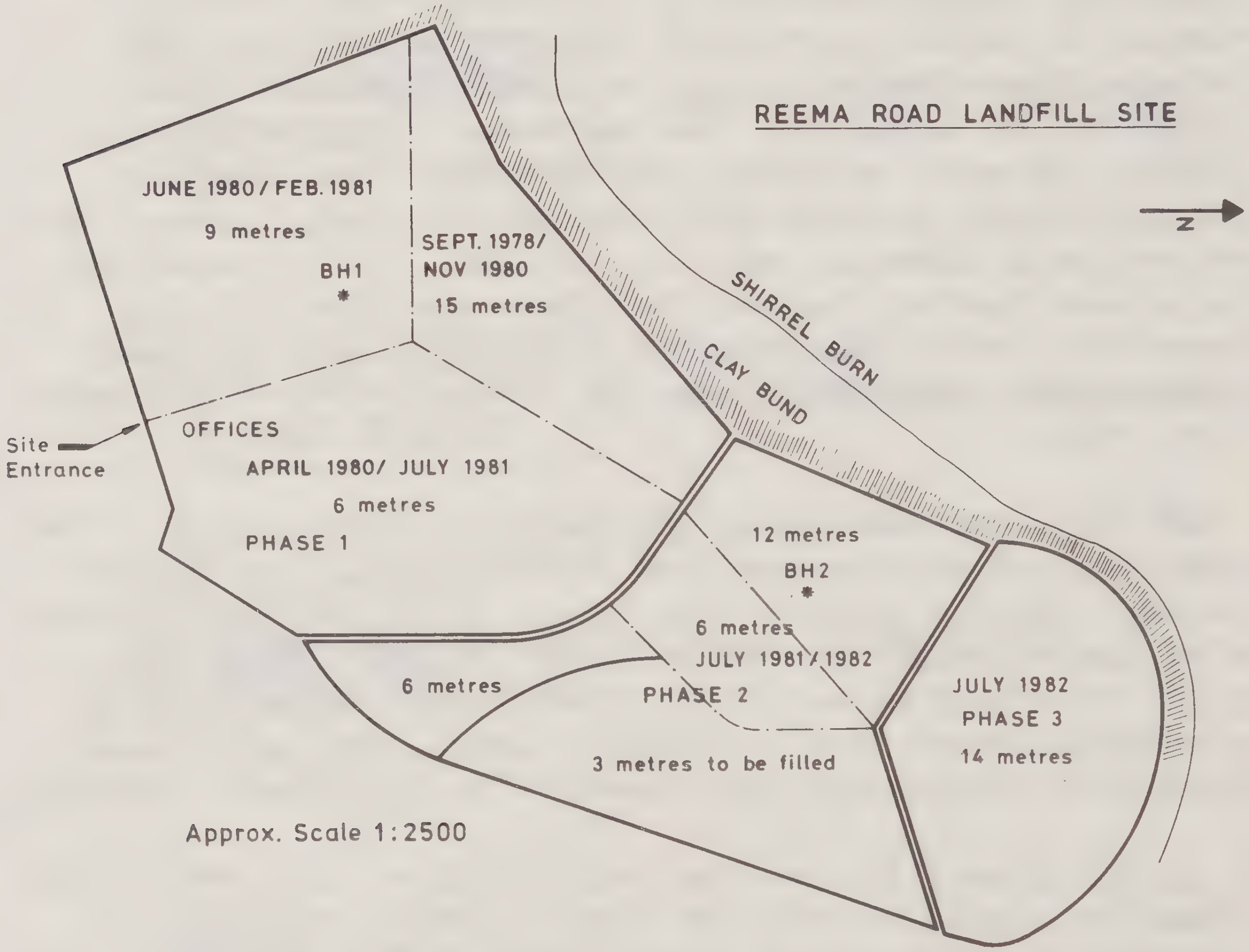
The only sure way of evaluating a site's gas potential is by measuring the performance of one or more gas wells. There are great benefits to be gained from testing a number of wells, preferably simultaneously, so that interactive effects can be properly covered. It is important to emphasise that extended duration testing yields the most valuable information. The landfill, consisting of perhaps 25% intercellular void space, has an enormous storage capacity for gas. It is essential to extend testing beyond the draw-down time for the reservoir until steady-state conditions are achieved, whereby the extraction rate is equivalent to the production rate.

NCB (CP) have developed two designs of extractor. The smaller unit is a rugged and transportable air-driven venturi eductor with a flow range up to 200 m^3/hour and a vacuum capacity of 750 mm water gauge. Using only a mobile air compressor it is completely independent of electrical power and inherently safe. The unit lends itself to individual well tests of 4 to 8 weeks duration.

A larger diesel (or electrically) driven unit has a fan rated at a maximum flow of 1200 m^3/hour, capable of a pressure head of 900 mm water gauge. This extractor has an integral moisture separator and water seal, with flow measurement and monitoring points accessible from a fixed working platform. It is used in conjunction with a 6 metre or 9 metre high flare stack and flame arrester. Two of these units were in continuous operation at the Garden Festival site for 9 months whilst permanent facilities were constructed. Another rig was used for 7 months continuous pumping from ten boreholes on NCB (CP)'s Merseyside joint venture from September 1983.

SINGLE WELL TESTS

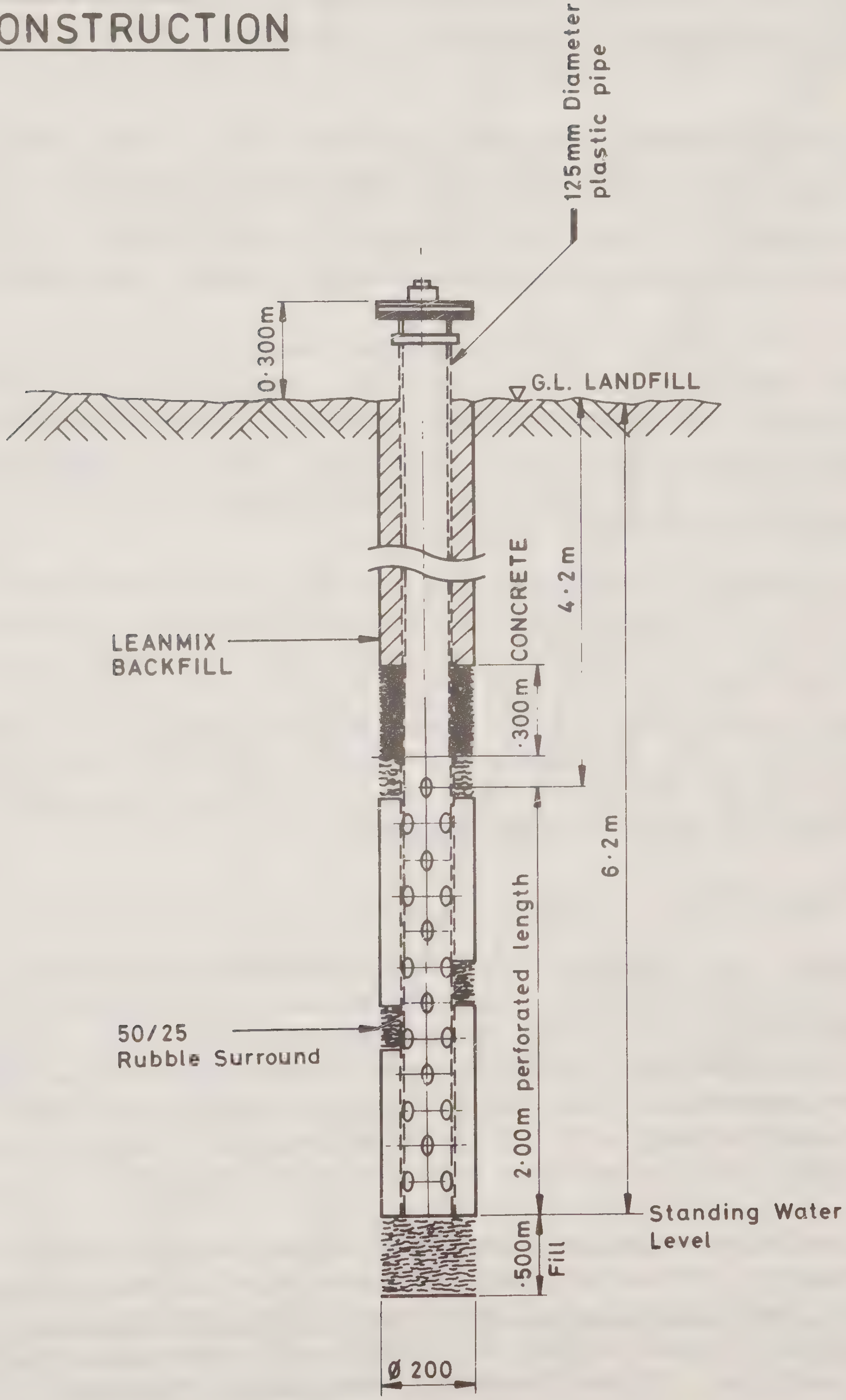
An investigation carried out in Scotland in March 1983 can be used to demonstrate the application of single well tests. The site was between 6 and 14 metres in depth, consisting of 450,000 tonnes of domestic and industrial wastes landfilled behind a clay bund over an area of 9 hectares to a compaction density of about 0.6 t/m^3. Two boreholes were constructed in areas having an age difference of about 12 months.



The boreholes were drilled until a standing water table was reached at 6.2 metres below surface. Although the site was mounded it became clear that the clay bund around the perimeter had effectively contained most of the water entering the site and there was no evidence of pollution of the local burn.

Two 125 mm plastic pipes, perforated over the lower 2 metres, were installed and backfilled to create a

DETAILS OF BOREHOLE CONSTRUCTION



good seal between the landfill and pipe well. 50 mm monitoring probes were also driven into the landfill at 15, 30 and 36 metres distance from the boreholes to enable in situ gas pressures to be measured at a depth of 5.5 to 6 metres.

Gas was extracted from each borehole for a four week period. The variability of flowrate with applied vacuum has been plotted for successive site visits which gives some measure of the time required to draw-down the reservoir of gas and achieve a semi-stable equilibrium.

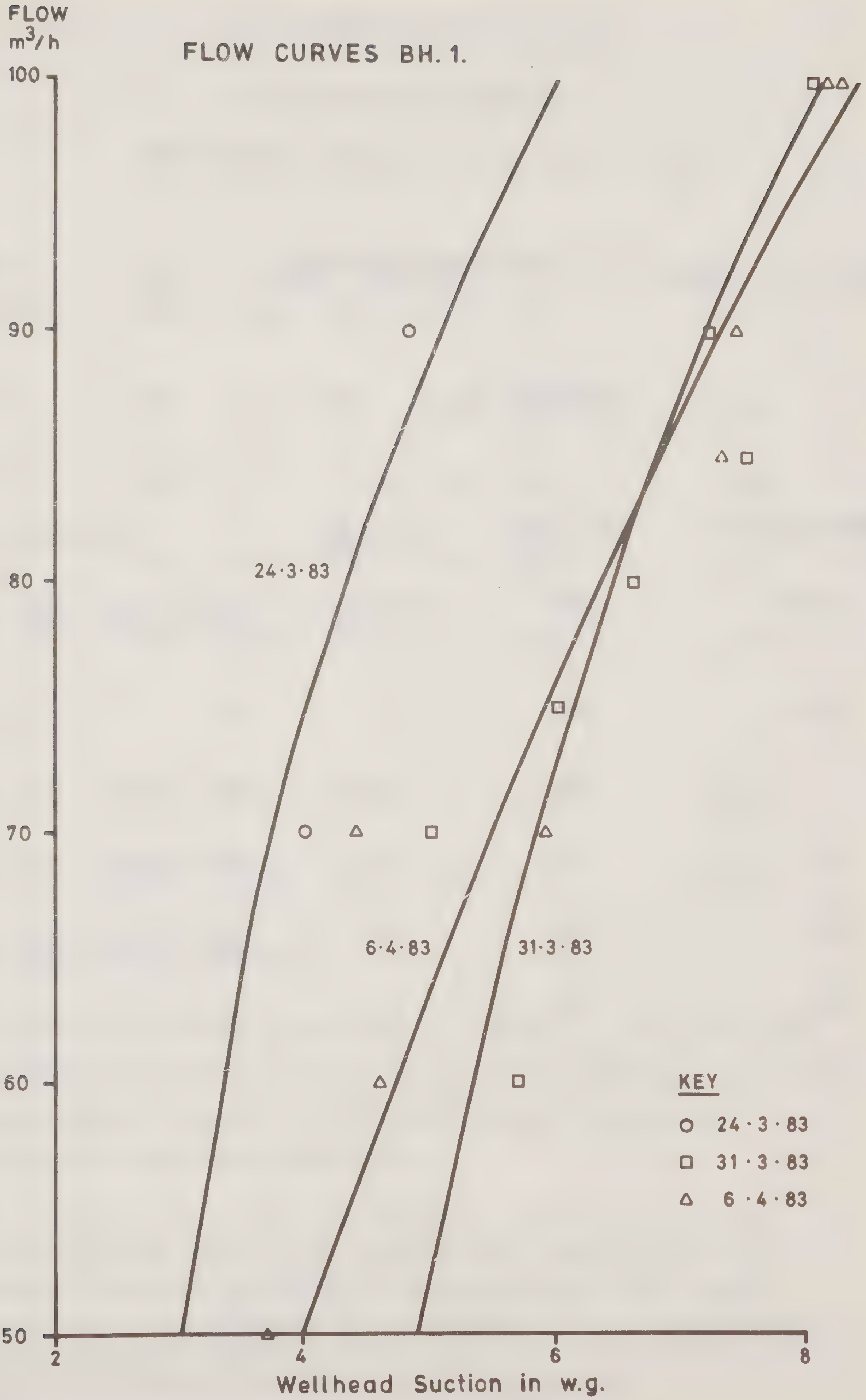
Typical flowrate, suction and gas analyses by chromatograph show how, in this case, the production remained reasonably consistent during testing. From these and other measurements it was concluded that the radius of influence of each well was between 40 and 60 metres at flowrates of 60 to 90 m^3/hour.

The estimated site yield was 1.6 million therms/year (0.157 × 10^6 Gigajoules/year) which implied a current decay rate in excess of 5 therms/tonne of waste/year. The half-life of decay on this very active site is likely to be only 4 or 5 years and projections of gas production into the future indicated that the yield is likely to be halved by 1990 unless further degradable material is added to the landfill.

MULTIWELL TESTS

A longer term pumping test was undertaken in Merseyside on a mounded landfill. Eleven wells were connected by a horseshoe main to the diesel driven extractor fan. The intention was to supply gas to an adjacent factory as an industrial fuel gas. Earlier single well tests indicated a radius of 50 to 60 metres at a flow of 50 cfm (85 m^3/h) with a methane content of 43 to 45%.

The sustained pumping supported these earlier projections. Eventually, 10 wells remained connected to the system and whilst each produced at different flow and quality, the cumulative results over six months of continuous operation have matched, if not bettered, the early findings.



FLOW CURVES BH. 1.

SITE INVESTIGATION RESULTS

BOREHOLE NO. 1

RUNNING TIME	GAS FLOW	SUCTION	ANALYSIS			
DAYS	CFM	IN W.G.	CH_4	CO_2	O_2	N_2
0.5	70	6	65			
6	65	7.5	62.5	34.6	0.7	2.2
13	50	6.8	59.3	38.4	0.5	1.8
20	55	8.1	65.7	33.4	0.1	0.8
26	60	8.4	64.4	31.9	0.9	2.8

SITE INVESTIGATION RESULTS

BIDSTON MOSS LANDFILL

CONTINUOUS PUMPING TRIALS 1983 - 1984

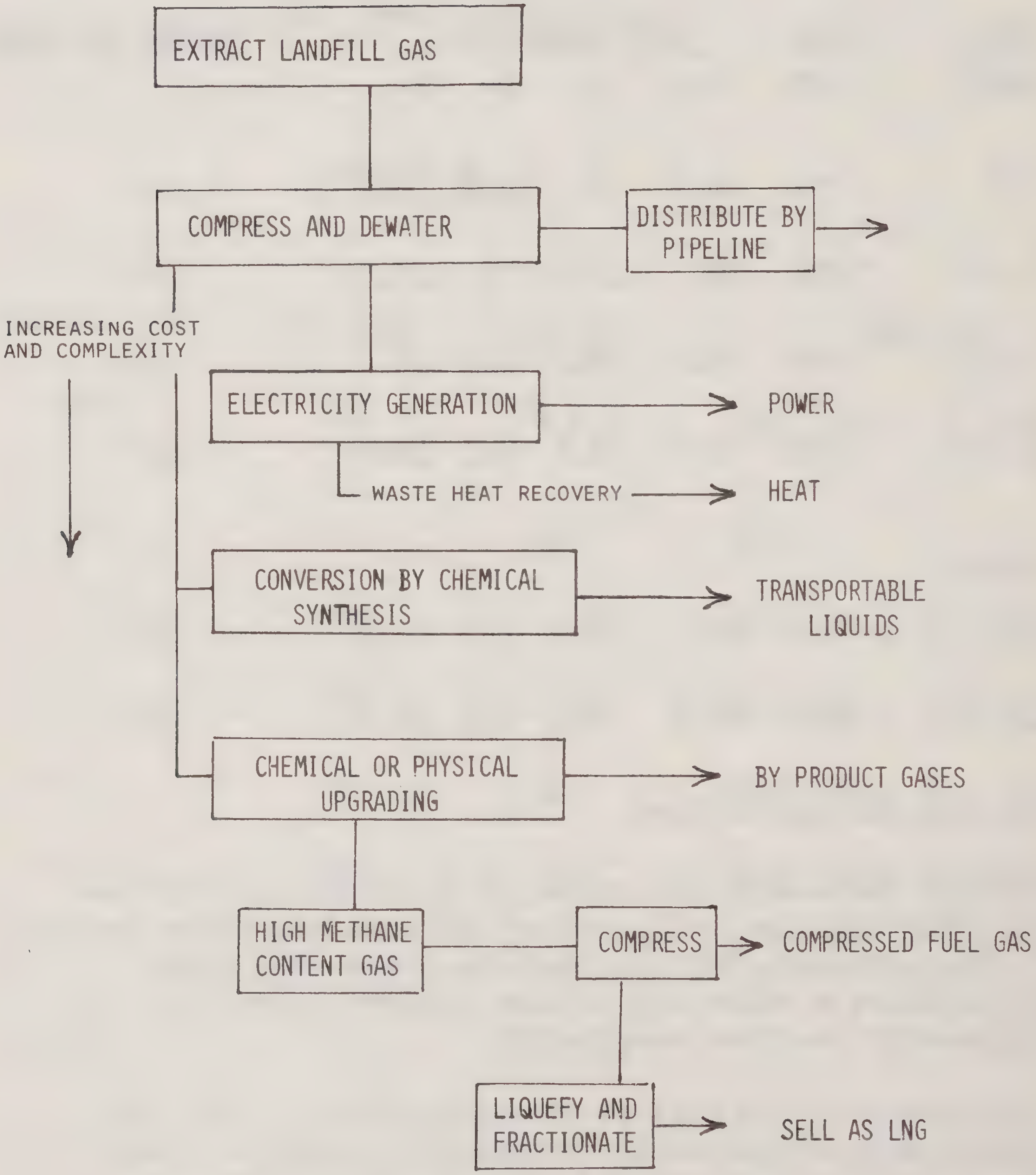
DATE	FLOW	GAS ANALYSIS				THERMS PER HOUR
(1983)	CFM	CH_4	CO_2	O_2	N_2	
1.9	495	60.4	30	0.1	9.5	180
6.10	495	50	27.8	TR	22.2	149
5.11	495	45.1	28.1	0.4	26.4	134
2.12	495	42.8	28.0	0.2	29.0	127
(1984)						
4.1	502	49.7	28.0	1.1	21.2	150
10.2	606	43.8	28.1	0.8	27.3	159

GAS UTILISATION OPTIONS

With an increasing awareness of landfill gas problems and opportunities, site owners and operators are looking at the potential for utilisation. NCB (CP) have constructed a hierarchy of use options graded by increasing cost and complexity.

The simplest and most profitable use has to be the direct sale of gas as an industrial medium Btu fuel. Treatment can be limited to compression, with some dewatering, and the gas then transmitted by pipeline. Sales prospects rely upon the proximity of a user or the ability to attract a consumer to the site.

GAS UTILISATION OPTIONS



The Energy Act 1983 has now regularised tariffs and terms for the sale of electricity to Area Boards. NCB (CP) have concentrated efforts to establish the costs and economics of power generation on the more remote landfills. For almost a decade now, NCB has generated power from colliery methane using turbines, dual fuel engines and spark ignition engines. This has been a profitable activity since it displaced the purchases of costly power from the grid, and with waste heat recovery for space heating, other energy savings could be made. However, it is too early yet to generalise about the scale and conditions at which generation using landfill gas will become profitable.

Looking at other potential for exploiting the more remote sites, chemical synthesis is being examined. This requires considerable input volumes and a long life to show any reasonable return. Some Water Authorities, dealing with sewage gas, are piloting work to remove CO_2 and H_2S to produce a bottled automobile fuel. This technology could later be transferred to landfill if appropriate.

DIRECT SALES TO INDUSTRY

To give a better understanding of the techniques and equipment employed for direct sales to industry, Aveley can be taken as an example. The site is 20 hectares in area, 35 metres deep and will be completed in 1986. 250,000 tonnes of domestic waste have been tipped annually since 1972.

Initially the site was drilled for testing using a shell and auger rig. This technique is suitable for holes up to 300 mm in diameter.

In constructing the permanent scheme a rotary auger was used to drill cased holes up to 750 mm diameter. Twenty 450 mm perforated plastic pipes were installed and connected to collecting mains across the site. A common 600 mm header running along the boundary of the site carries the gas to the extractor plant.

During construction and commissioning of the collecting network each well was tested for output whilst gas was extracted using a diesel powered extraction rig.

The pumping station consists of two buildings, one housing the gas pumps and dryers, the other incorporating a control room, switchroom and calorimeter house.

Over 3000 m^3/hour of gas at 55% CH_4 concentration is drawn off the site using liquid ring pumps which lift the pressure to 1.7 bar. After cooling in a shell and tube heat exchanger, the gas is chilled to about 3 °C using a refrigerant drying unit. The gas is then metered before transmission through a 4 km ductile iron pipeline to the consumer, crossing the A13 trunk road and a local river.

The customer for the gas, worth more than £900,000 per year, is Thames Board Limited at Purfleet. TBL manufacture packaging card from waste paper. In the production process they use 4 to 5 MW of power which is generated from a single pass-out steam turbine. The 70 tonnes per hour steam boiler is fired by landfill gas and natural gas or heavy fuel oil. The landfill gas supplies about one third of the heating load and the combination firing system is micro-computer controlled.

This investment, in excess of £1.5 million by the three parties involved, represents a rare example of co-operation between the public and private sectors, producing benefits to the taxpayer, local residents and to the ratepayer and shareholder. We sincerely hope that this will be the forerunner of many such schemes where NCB expertise can be put to further profitable use.

nsca

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14 – 17 OCTOBER 1985
SCARBOROUGH

– AIR POLLUTION CONTROL – SITUATIONS REPORT – INDUSTRY, LOCAL AUTHORITIES AND CONSULTANTS IN A CUT BACK ENVIRONMENT

– By –

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INTRODUCTION

Individual Consulting specialists and firms of consultants with environmental expertise have found respectable business in the relationships between local authorities and industry, particularly in:

(a) the planning of new developments;
(b) the control of existing problems;
(c) clean up after industry has gone.

Traditionally the local authority could always afford to buy in specialist knowledge. Industry also had permanent staff specialists and the central government control agencies were also active and could provide active assistance.

Now all this has changed.

ECONOMIC STATE

The changes have occurred over a number of years. With local authorities, the cutbacks in expenditure started some time ago and have become progressively more stringent.

The cutbacks in industry have had several interactive effects with reductions in:

(a) development and research;
(b) operation and output;
(c) expenditure to maintain production;
(d) the standards of environmental protection and safety.

Many more companies are now in marginal viability and claim the rights of organisations in the cutback environment, "the right to pollute to protect employment".

On some occasions this precept is dressed up nicely for the electorate; in others the truth comes through.

Unfortunately, in many cases the "need to pollute to remain economic" is necessary, especially in capital intensive industries. The economic advantages of the reduction in labour costs have been far over-balanced by the costs of capital. Reductions in labour costs have been achieved by cuts in maintenance and control and have resulted in losses in reliability in production and cost increases. The resulting increase in pollution is considered as little more than an unpleasant byproduct.

In terms of planning the beneficial impacts of the generation of employment takes precedence over the adverse impacts of pollution, noise and visual intrusion.

It is with some bitterness that it is possible to observe how the influence of environmental control built up throughout the early 1970s has waned since the end of the decade. The results of cutting back have been the production of new slim lined systems for environmental control.

The adequacy of the new slim or stream lined environmental control facilities can only be seen when they have to be applied. It would now appear that the economy is on the move and in some areas consultancies such as ours are enjoying a period of expansion, and the problems of the cutback economy are emerging.

Where an over slimmed down system is exposed to growth the results can be disappointing with lack of manpower and capitalisation resulting in the generation of delays and losses in quality. Mitigation becomes important and standards can be changed to satisfy more limited goals.

The new slimmed down system is seldom healthy and can be vulnerable to the pressures of growth.

With consultancies, the position is very similar except, of course, where diversification could occur or where the fall-off in home business was overcome with work from abroad.

NEED FOR CONSULTANCY SERVICES

The climate in which problems exist, know-how is lacking, and where there is readiness to relax standards, is ideal for the operation of good environmental consultants.

The need is for a new type of environmental service based not on what was considered desirable but on the concept of the "best practicable means" between the authorities and industry. Best practicable means here refers to control and response, not only to abatement.

Authorities have to accept the limitation of their resources and act within their powers. Industry, with the greater flexibility and funding, will have to make the accommodation through the policy of the developer or polluter pays.

My suggestions for practicable means in planning and in public health control are set out in the next two sections and are based on the use of consultants.

ECONOMICAL ROLES IN PLANNING

The introduction of a requirement for Environmental Impact Assessment (EIA) should provide a valuable tool for the planning authority in order to simplify the procedure and eliminate the need for the authority to employ specialist environmental advisers.

However, it appears as though it will be some time before the potential of EIA is fully recognised by developers. Its acceptance will be slow with an initial tendency for developers to produce glossy documents strong on environmental assessment and weak on impact prediction and control.

In the meantime, we would like to make the following suggestions for encouraging progress:-

(a) planners must recognise that at outline planning application stage it is only reasonable for the developer to produce preliminary design details;

(b) the developer must recognise that unless his preliminary design details show that the proposals are compatible with the environment, refusal will result;

(c) with the process industries the full assessment of environmental impact or safety cannot be completed without information which has to be produced in the detail design stage of the project. No developer can afford to carry out detail design these days without a valid outline planning permission.

Successful solutions can often result from cooperation between the developer and the authority, formalised in planning conditions, for the requirement of detail design audits to be carried out by third party experts at the expense of the developer.

Benefits to the developer include transfer of limited funds from the full assessment of preliminary to detail designs, allowing the optimisation of control of impact and protection of the environment.

Benefits to the authority include:

(a) the achievement of the primary objective of screening the project to ensure environmental compatibility;

(b) assessment of the detail design as it progresses, ensuring that the granting of a planning permission is not a licence for re-design and that environmental protection is kept under constant consideration rather than being placed on the 'back burner'.

What if the developer fails to cooperate? The sole recourse is for the authority to use the only 'teeth' available, and delay. If necessary an authority can cause delays and even go as far as the threat of forcing the application to public inquiry. This is easier said than done. However, the resourceful authority can produce reasons for their actions. This course of action is of relatively low cost to implement.

The developer's chief threat is to move the project to the jurisdiction of a more responsive authority. The politics which result have to be taken on a case by case basis but much money has already been committed by the developer by the time he has reached the stage of making the planning application.

The best solution is for the authority to persuade the developer to employ a consultant in whom the authority can place an element of trust.

ECONOMICAL ROLES IN ENVIRONMENTAL CONTROL

Most authorities adopt the 'carrot and stick' philosophy in dealing with pollution problems in existing works.

In the past the carrot has been mightier than the stick.

In the cutback environment, successful industries have been forced to adopt more devious roles, and as a result the carrot has become less efficacious.

For any local authority, waiting for improvements to take place, monitoring slow, gradual progress with the cascade of delays which naturally arise from limitations in financial manpower and expertise resources can be just as expensive as the institution of summary proceedings.

In the cutback economy the best practicable means for the authority lie in the application of its powers rather than in the use of precious resources to subsidise procrastination by the polluter.

In problems covered by the Public Health Acts the law requires action. Authorities should perhaps think twice before delaying action while issues of the best practicable means of abatement are resolved. Opinions have been expressed that it is for the defendant to plead the defence of 'best practicable means', and it is for the Court, not the authority, to decide the issue.

In most cases where an operating company is in trouble with an authority, it is entirely practicable for the company to employ consultants to assist with abatement action or to confirm that the best practicable means of abatement are being used. There would appear to be little or no justification for the authority to spend ratepayers' money in fully evaluating the defence of the polluter.

The best course of action for the authority is to recommend the polluter to ensure that a competent consultant is hired from the outset, and not at the second or third attempt.

WHICH CONSULTANT?

Consultants come in a wide variety of types. The most convenient classification is in terms of the size of the firm by the number of specialist advisers they can provide and in the range of interactive specialities which can be involved:

(a) individuals;
(b) small firms, 1 to 5 specialists;
(c) medium firms with 5 to 20 specialists;
(d) large firms with 20 and more.

Individual consultants fall into two groups:

(a) those who live to work - generally the retired professional specialists;
(b) those who work to live - generally younger professionals who like working on their own.

Fee rates for individuals may be low, perhaps in the range of £20 - 30 per hr. The largest jobs an individual can take on are generally in the range of £10,000 per year. The successful individual is in constant danger of becoming over-committed and there may be problems in the achievement of time scales. However, due to the importance of reputation, commitment is guaranteed.

As the size of the firm increases so do the effects of overheads and the fee rates grow in proportion.

With small and medium sized firms the top specialists are still involved with the work on small projects. Although fee rates may be substantially higher it is still possible to ensure commitment from the top of the firm. Small contracts, those less than £5,000, can be handled with confidence but the firm is always looking for larger scale work. The more that larger contracts are won, the greater the productivity, with the overhead costs making a smaller fraction of the total fee cost.

Large firms may have lower fee rates than the medium scale firms because they can provide more junior staff to carry out the work. In fact with small contracts, senior management are usually unlikely to be involved except at the start and finish of the project. Large firms have flexibility and resources and can thus provide the fast response to a call for help. Small jobs can be blended with large contracts. In fact small jobs can even be run as lost-leaders to bring in bigger follow-up contracts where a larger job can be foreseen.

Again larger environmental firms usually provide the full range of services which the large contracts (£500,000 and more) require.

It is important to assess the strength of the Consultant to ensure compatibility with the project.

With large firms it is important to know exactly who will be responsible for the work and exactly who will be doing the work. It is these people who must be compatible with the project, not the general experience of the firm.

Specialists tend to give greater consideration to solutions from their own fields of specialisation. The atmospheric dispersion man will often give a more detailed evaluation to the use of chimneys rather than to control at source, which is the field of the process engineer.

Where the problem would appear to require engineering abatement it might seem that engineering specialists would be preferred to assessment technologists.

SELECTING CONSULTANTS

If, as an authority, you have a chance to recommend that a developer or polluter should use a consultant, it is important to ensure:

(a) the selection of the Consultant is based on grounds of ability rather than economy;

(b) the Consultant has the appropriate experience which includes at least one similar job;

(c) the individuals to work on the job are the right guys for the task.

If an authority requires consultants it is important to make the additional checks to establish that the size of the contract is compatible with the resources of the consulting firm.

In selecting consultants, always describe the problem clearly and invite their ideas for approach and solutions. While much emphasis must be placed on formal proposals for the contract, it is essential to determine flexibility and ingenuity. This can be assessed by interview. Most consultants will be prepared to make presentations for prospective clients and to show-off the individuals who will be working on the project.

IN CONCLUSION

In the cutback economy, it is up to the authorities to make the running in environmental protection policy. Despite limited financial resources, it is the authorities who will determine the level of response to be obtained from industry. It is also up to the authorities to ensure that the quality of the industrial response is adequate.

Without the financial resources to employ consultants the only option for local authorities is to ensure that consultants are employed by industry. It is important to ensure that the consultants hired are the best for the job in hand; this is a question of 'horses for courses'.

It is important for industry to make the right approach to the authorities. In the selection of consultants to work with local authorities, industries must recognise the difficulties of the authorities and the rewards which can be gained through cooperation rather than in the expense of confrontation.

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– AIR POLLUTION CONTROL – SITUATIONS REPORT – CONTROL OF PARTICULATE EMISSIONS

– By –

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Energy production and use, particularly with regard to the combustion of fossil fuels, is the origin of most of the air pollution in industrialised countries. All efforts to use energy more efficiently will have a benefit on air quality, and so the increasing costs of energy are some incentive to air pollution control.

In recent years there has been a general growth in public awareness and concern about environmental problems. Pressure for action against certain problems is strong, yet there have been conspicuous successes in dealing with traditional forms of air pollution of which particulate matter is a significant feature. Many of the remaining difficulties have long been recognised and these will be highlighted in this paper together with some of the current problems.

The World Health Organization[1] defines a particle as "a discrete element of a material regardless of its size; a small part of a solid or liquid substance".

By comparison, the National Society for Clean Air (NSCA) Environmental Glossary[2] definition of particulate is "a fine solid particle (or fine liquid particle) found in the air or emissions: such as dust, smoke or smog".

Consequently we understand particulate matter as being the wide range of pollutants from smoke, grit, dust and fumes to things like toxic metals and asbestos.

Traditionally of course, the most familiar example of particulate matter in urban air is smoke. A fascinating history of the politics behind the fight for the control of this form of air pollution has been written by Ashby & Anderson[3] and it is interesting to compare changes in policy throughout the last few centuries. Early in the Second World War, for example, the production of dark smoke was positively encouraged as a form of protection against enemy attack from the air. In the same period of time but in another context, H. Goering is reported as saying:

> "Control the air and we will win the war"

Certainly this is true also of combustion, and the principles of efficient combustion of fuels to avoid producing smoke had long been understood.

As we all know, despite repeated attempts to deal with this form of particulate pollution it was not until the Clean Air Acts supported by social and economic pressures for cleaner and more efficient fuel use that success was achieved. Hopefully, the National Industrial Fuel Efficiency Service Ltd, (NIFES), first as a branch of the Ministry of Fuel and Power and more recently as a private company of consulting engineers has contributed towards this achievement.

The controls on particulates in the form of smoke from stationary sources[4] are now nearly 30 years old. The question has often been asked as to what extent these limits on smoke emissions are now out of date and too lenient. However a discussion of combustion efficiency and smoke is not the purpose of the present paper.

If we consider particulate of rather large size, we come to what is commonly known as "grit and dust" in the context of the Clean Air Acts, and "particulate matter" in relation to processes controlled by the Industrial Air Pollution Inspectorate. One of the Chief Alkali Inspectors of the 1930s, W.A. Damon, criticised bluntly the lack of progress in smoke abatement, and his reports also highlighted the more difficult problems of dealing with grit and dust.

It was not until the Clean Air Acts that limits were set for particulate emissions under the provisions of Section 2 of the 1968 Act[5]. The limits followed from the recommendations of the Working Party on Grit and Dust Emissions whose report was published in 1967[6]. A report of the Second Working Party[7] related to emissions from incinerators, cupolas and miscellaneous furnaces. While draft regulations were prepared it is unlikely that they will become law, certainly while the industrial economic situation remains depressed, owing to the cost to industry of meeting the standards. This situation is not a new one. In the 1840s smoke was low in the priorities for public concern and Britain was recovering from a trade depression "... when every shilling is an object to the manufacturers ...".

In respect of emissions from processes registered under the provisions of the Health & Safety (Emissions into the Atmosphere) Regulations 1983 (SI 1983 No 943) presumptive emission limits apply for particulate matter and other pollutants from a wide spectrum of industry. These powers together with those from the Clean Air Acts provide the main emission standards in the United Kingdom, although others will no doubt follow from the EEC as in the case of emissions from major combustion sources, to which reference will be made later.

A major implication of the existence of emission limits is that there must be measurement of emissions to check compliance and the Clean Air Acts allow for this. Further powers to measure emissions are provided by Sections 79 and 80 of the Control of Pollution Act 1974. It is significant to note that the powers to measure particulate emissions under neither the Clean Air Acts nor the Control of Pollution Act 1974 have been used to any great extent. This is indicated by statistics produced by the Institution of Environmental Health Officers (Table 1). The Royal Commission on Environmental Pollution in its 10th Report[8] drew attention to the lack of use of the powers in the Control of Pollution Act and commented that only five local authorities had issued formal notices under Section 80. The Commission recommended that these powers should be made mandatory. There can be no doubt that the Government Circular promulgating the regulations[9] emphasised that the powers in the 1974 Act were discretionary and that the resources necessary to make use of the powers must be found from existing budgets. Further advice to measure grit and dust emissions only after full consideration of the costs and time involved was given in relation to Clean Air Act powers[10]. These two factors must account for some of the reluctance to undertake particulate emission measurements, but the method of measurements itself is by no means easy to carry out. Once again, NIFES has been involved in this area of pollution control to a significant degree. In fact, we have probably carried out more emission tests in the country than any other private organisation. Let us look at some of the practical aspects of this problem.

EQUIPMENT PROBLEMS

To comply with the statutory requirements or commissioning/acceptance testing for particulate emission, manual sampling is the only reliable system. The manual technique consists of extracting a sample under controlled conditions from a duct or chimney so that the sample is representative of the total emission from the installation.

A wide range of equipment is available, but basically all consist of a sharp-edged nozzle and probe with a collecting device and a sampling pump, which has a control unit for controlling the gas flow rate and volume sampled. The most common system in use in the UK is the BCURA apparatus and this is the one generally used when testing to the requirements of the Clean Air (Measurement of Grit and Dust) Regulations 1971.

The BCURA apparatus has proved its worth over many years in its flexibility and consistency in use, but the system was designed over 30 years ago at the British Coal Utilisation Research Association (BCURA). There have been some minor modifications but the basic system has remained unchanged. In addition, the BCURA apparatus was originally developed for coal fired boilers but its design, which allows the samples to be collected inside the flue and to utilise its own collector as the sampled gas measuring unit, made it ideal for wider applications. The system is now used, for example, by the Health and Safety Executive as their standard equipment for particulate emission testing on a wide variety of process plants. It should however be appreciated that the BCURA apparatus does have limitations and is certainly not a "universal testing unit".

We can summarise some of the limitations of the BCURA cyclone and probe equipment as follows:

a) the flue gas must not exceed 300 °C for internal sampling, although this can be overcome by using the system as an external sampler. This introduces another basic problem of deposition within the probe before the collector and which is a shortcoming of all external sampling systems;

b) if the gas stream has a high moisture content fouling of the filter will occur and there will be subsequent problems of drying and weighing;

c) there are difficulties of handling the equipment in large ducts, whereas in small ducts there are problems of locating the sampling nozzle in the correct position without modifying the duct;

d) if the duct is very small the area taken up by the collector in the duct can be unacceptably large;

e) break up of particles in the cyclone collection is a problem if accurate particle sizing is required of the sample collected;

f) sticky deposits can adhere to the cyclone and are therefore difficult to remove.

Under the Clean Air (Measurement of Grit and Dust Emissions) Regulations tests have to be carried out to BS 3405 "Method for the measurement of particulate emission including grit and dust (simplified method)", the latest edition of which was produced in 1983. This standard lays down the equipment which is considered acceptable and includes the BCURA apparatus. In the present standard reference is only made to two other available assemblies, the Mark 111A filter apparatus developed by the CEGB and the NCB Mark I and II cyclone probe with and without a backing filter. Although the standard does not eliminate other equipment, there is no scheme available which can give other equipment approval for use.

It will be appreciated from what has been discussed that the present "state of the art" regarding the apparatus for emission testing has not really progressed in the last 20 years. The system is still therefore difficult to use, time consuming and expensive.

The hope for an inexpensive, reliable and accurate continuous monitor is still a long way off. Certainly automatic mass emission monitors and optical methods are available but all have their problems of calibration and accuracy for long periods and none is acceptable as a means of determining the emission levels under the present regulations.

PROCEDURE CHANGES

The current BS 3405:1983 has introduced tighter controls on testing. The following main provisions must be met for compliance with BS 3405:1983.

i. Velocity Measurement
  a. Water droplets not present.
  b. Gas velocity positive and pitot static pressure greater than 0.05 mbar.
  c. Direction of gas flow within 20 ° of the flue axis.
  d. Suitable gas velocity profile (greatest to the lowest pitot static pressures less than 9:1).
  e. ± 5% limit on change of average velocity during sampling (± 10% of the sum of the pitot static readings).

ii. Dimensions and Temperature Requirement
  a. Suitable gas temperature profile.
  b. Flue dimensions measured to ± 10mm/m.

iii. Sampling
  a. Area of sampling apparatus shall be not more than 10% of the flue area.
  b. Sampling plane should be more than two flue diameters from upstream bend or obstruction and one diameter from downstream obstruction or disturbance.
  c. Sampling from centroids of equal area.

d. Eight point sampling where necessary.
e. Sampling at each point for not less than 3 minutes.
f. The nozzle area times the sampling period must be constant during cumulative sampling.
g. Maintain required flow velocity during sampling.

iv. Weighing and Analysis
a. Minimum mass of material collected shall be not less than 0.3% of container mass.
b. Ratio of results for emission shall not be more than 1.5:1.

A failure to meet any one item has the result that the test does not comply with the full provision of BS 3405.

On many plants, the requirements for the positioning of the sampling points cannot be met and although testing can be carried out under BS 3405, the test report or any statement of results must clearly indicate that this is the case. Unfortunately, the above relaxation of the requirements is often not sufficient as due to the variations tests often fail other requirements particularly those associated with velocity measurements.

In actual test situations up to 40% of the tests carried out are outside the requirements of BS 3405 and initially about 25% could be aborted in the first visit due to non-compliance of Health and Safety requirements, particularly with regard to access and working platforms. It is imperative therefore that prior to testing an initial visit is made to ensure that not only is the plant in an acceptable state for testing but all Health and Safety Requirements have been met.

Typical problems associated with non-compliance of the BS 3405 requirements are:

1. suitable sampling positions on existing plant. Even some new installations are still not designed to allow for emission testing. Too often the plant is designed and installed and when emission tests are required no suitable positions can be found;

2. problems of fluctuating loads or plant conditions. It may be that these fluctuations can be overcome but by imposing control on the plant this can introduce a bias in the testing. It may be that it is under the changing conditions when problems of particulate emissions occur, and so the uniform test conditions imposed represent a false situation.

   Further problems are being encountered with the increase in automatic controls on plant. This is particularly highlighted in plants such as incinerators for which auto-draught control can create conditions which make testing outside the BS requirements;
3. wet exhausts when water condenses in the filter arrangement;
4. sticky deposits which adhere to the unit and therefore have to be washed out, dried and then weighed. This type of handling can result in significant errors being introduced;
5. sampling after cyclone arrestment plant, even when a fair distance away from, can still lead to unacceptable velocity profiles owing to disturbance in the gas flow.

EUROPEAN STANDARDS

The foregoing discussion has been concerned with UK practice but it must be realised that with our membership of the EEC and the common concern in the European Community on pollution, new particulate emission standards are likely in the near future which will not only lay down emission levels but must also specify the procedures for particulate sampling. At present there are significant differences when comparing national standards. For example the number of sampling points for the German, French and British Standards are shown in Table 2.

Another difference is that the position of the sampling point downstream from a disturbance is from 1 diameter in the British Standard to 5 diameters in the French Standard. Not only do the national standards have procedure changes, but there are equipment differences as in the nozzle design requirements and filter characteristics. It is therefore imperative that standardised techniques/procedures and agreement on testing equipment are established. However, this could lead to problems in the UK. The UK philosophy on emission testing is summed up in the title of the British Standard which states "Simplified Methods". If more elaborate testing is introduced, then particulate emission testing becomes even more time consuming and costly.

Not only are there differences in national standards for sampling but the permitted levels of emission vary throughout the EEC for different processes and this is further complicated by the use of different units.

Graph 1 represents just one aspect related to oil firing of plant in which the material being heated does not contribute to the emission. In order to have a common basis for comparison the emission has been related to the output of the plant, i.e. mg/MJ.

This complication of the units used by different countries is shown in Table 3.

It will be seen from Graph 1 and Table 3 that the allowable emissions in the UK are higher than in either France or Germany and therefore this raises the question of whether our standards should be modified. It is likely that the UK will have little choice as there is an EEC Council Directive on the limitation of emission of pollutants into the air from large combustion plants under consideration. This Directive covers SO_2, oxides of nitrogen and dust emission. The proposed emission limit values for dust are given in Table 4.

These limits are significantly more demanding for plants which fall into the range covered by the current statutory requirements and no distinction is made between firing with liquid and solid fuels, unlike current UK practice.

An approximate comparison between the UK and these EEC proposals is shown in Graph 2. It should be noted that the directive refers to "dust", whereas in the UK statutory requirements, the definition is "grit" (above 75 micrometers) and dust (below 75 micrometers but greater than 1 micrometer); however, this would not alter the situation significantly since in the UK Regulations only from 20 to 33% of the emission can exceed 76 micrometers.

The UK control of emissions has always been on the basis of "best practicable means" and in fact a defence in the Regulations is that the "best practicable means" have been used to prevent the emission. The present statutory levels on emission and those used as guide-lines, (i.e. Report of the 2nd Working Party) together with the "presumptive limits" for scheduled processes all take into account the financial implications and current technical knowledge. Therefore the emission limits are achievable by operators of plant without major financial burdens being imposed. If emission standards are increased by the EEC the financial implications to operators of plant could be significant. Similarly there could be considerable financial implications for the enforcement agencies because the UK philosophy is to ensure that there is compliance with standards; this is unlike the situation in some countries where there are higher standards but the agencies do not or cannot enforce them.

What is the current situation with regard to testing? As indicated previously the position is still summed up by the "1967 Grit and Dust" Ministry Publication[10] which stated that it was not envisaged that all boiler and furnace emissions should be tested but only those thought to be causing excessive pollution since testing is both costly and time consuming "and should not be undertaken lightly".

In the North West, NIFES, who carry out most independent testing, have done 14 tests in the last two years and these tests have been the result of complaints or as part of commissioning/acceptance tests on new plant. Considering the number of plants in the North West, and the number of complaints that arise, it will be appreciated that independent emission testing is certainly "not undertaken lightly". It is interesting to note that the emissions measured in the majority of the tests meet the requirements. Usually any problems are associated with the operation of the plant and can be of an intermittent nature with the result that they are not covered by standard testing. Typically acid smutting with oil fired boiler plants is a main cause of complaint while in coal fired boiler plants, sootblowing, smoking and generally poor operation are the problem areas. None of these problems is within the scope of standard particulate emission testing.

Is particulate emission testing likely to increase?

If new standards for emissions are developed and are enforced, then increased testing will be necessary in order to comply with EEC requirements. As discussed previously, the present policy in the UK is to carry out measurements only when there are complaints from the public drawing attention to a problem plant. Even at this stage measurement is a last resort. With new and more demanding standards, much more general testing would be needed. A further suggestion that measurements may need to be carried out more often in the future comes from the Campaign for Freedom of Information. A recent Private Member's Bill in the Commons aimed to implement a recommendation made by the Royal Commission on Environmental Pollution that the public should be entitled to the fullest possible information. The Government accepted the recommendation in principle and said that it wanted to see the uniform implementation of the Royal Commission's recommendations between existing pollution control legislation. If the public want information about emissions, it is not satisfactory to say they are "good", "bad" or "indifferent". Information means data and the only way to supply it is by measurement.

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TABLE 1

MEASUREMENT OF EMISSIONS*

Clean Air Act 1956 Section 7

Directions made	Nil
Notices served	Nil
Plants where measurements taken	Nil

Clean Air Act 1968 Section 5(3)

Directions made	Nil
Notices served	Nil
Plants where measurements made	1

Control of Pollution Act 1974 Section 80/81

Notices served	8

* Data from Institution of Environmental Health Officers, Annual Report July 1983.

TABLE 2

COMPARISON OF SAMPLING POINTS FOR EMISSION MEASUREMENTS.

Country	Standard	No.of Sampling Points
Germany	VDI	4 per m^2 (20 max.)
France	NF	Depending upon duct size
U.K.	BS	4 - 8

TABLE 3

MAXIMUM PARTICULATE EMISSIONS OF LIQUID FUEL BURNING AT THE RATE OF 4000 THERMS (422 GJ)

County	Ref.Date	French System mg/th(1)	German System mg/Nm^3	U.K.System kg/hr
Germany	1971	60	50	6
France	1975	150	131	15
U.K.(2)	1971	220	186	22
Belgium	1971	250	212	25

Note: (1) th = thermie = 4.1855 MJ.
(2) Based on heat output of plant.
(3) 100 mg/Nm^3 = 118 mg/th at 15% excess air.

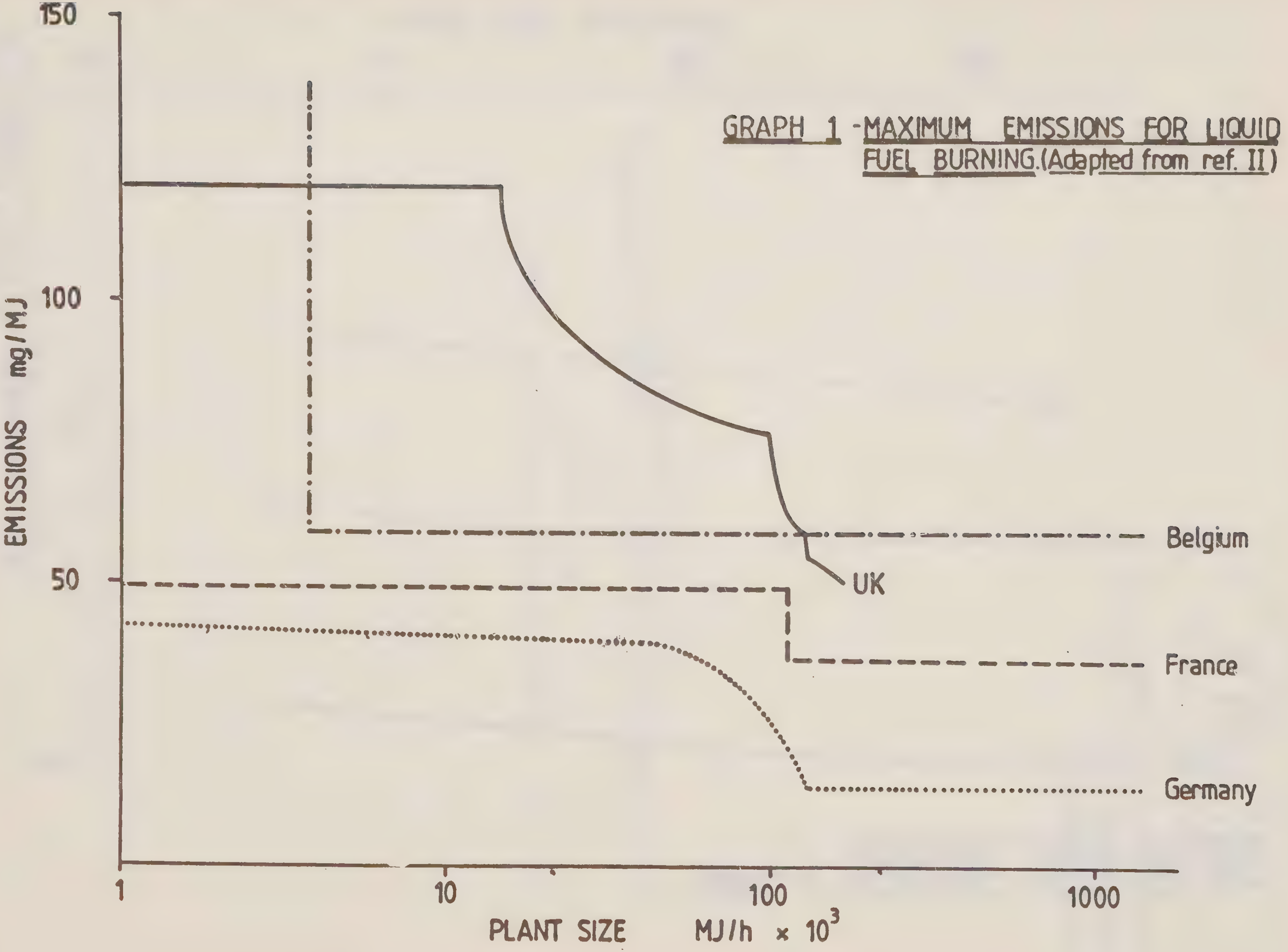
Adapted from Reference 11.

TABLE 4

PROPOSED EEC EMISSION VALUES OF DUST IN WASTE GASES UNDER STANDARD CONDITIONS

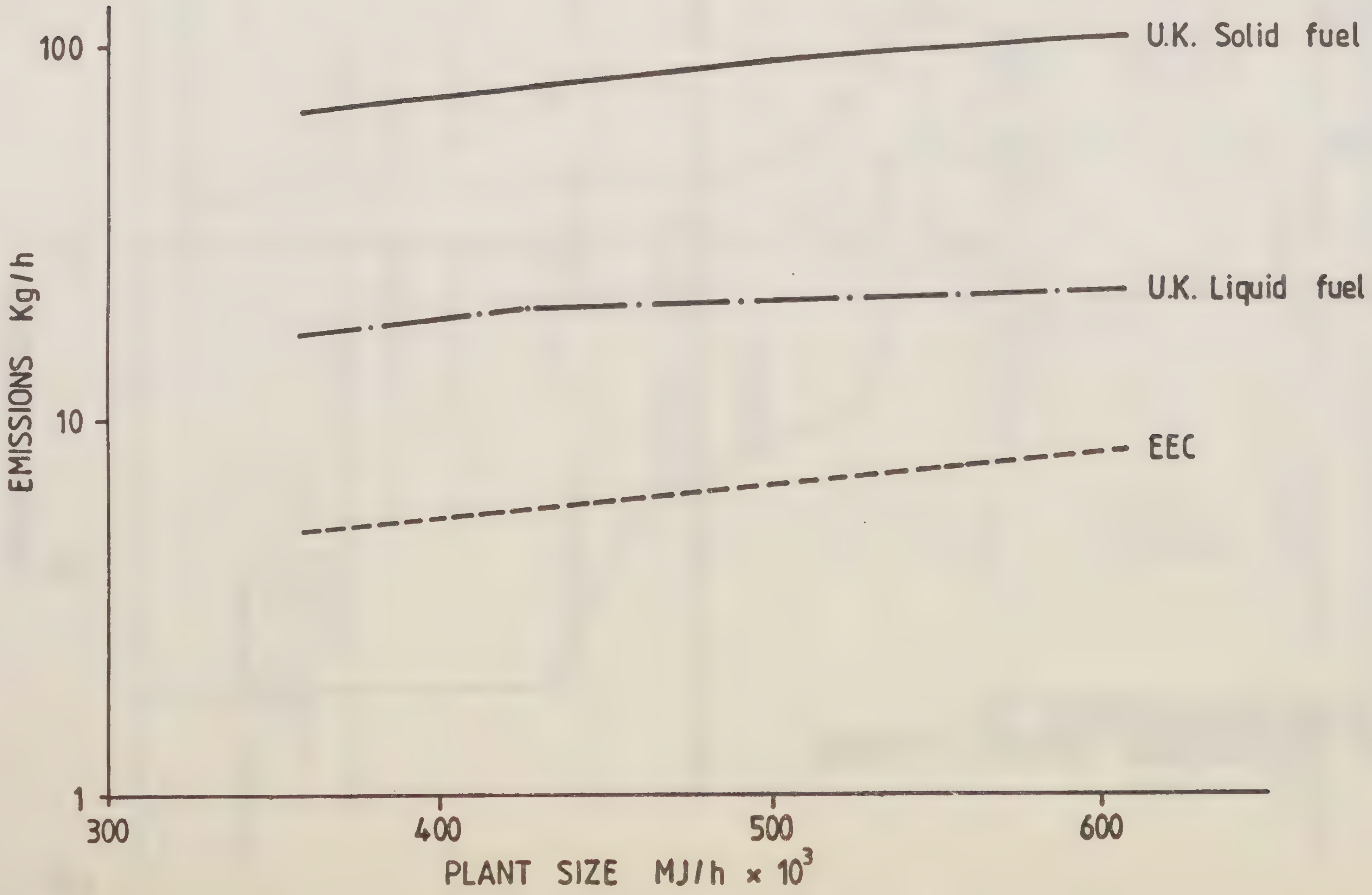
Type of Fuel	Plant Size MW	Plant Size 10^6 Btu/hr	Emission mg/m^3
Solid	300-100	1023.6-341.2	< 50
Liquid	300-100	1023.6-341.2	< 50
Gaseous	300-100	1023.6-341.2	< 5 General < 10 Blast Furnaces. < 50 Steel Industry (gases used elsewhere)

Data derived from reference 12.



GRAPH 1 - MAXIMUM EMISSIONS FOR LIQUID FUEL BURNING.(Adapted from ref. II)

GRAPH 2 - APPROXIMATE COMPARISON OF PARTICULATE EMISSION STANDARDS



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– INDOOR AIR POLLUTION – HUMAN EXPOSURE TO RADON DECAY PRODUCTS

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INTRODUCTION

Much concern has been expressed about the radiation exposures resulting from radioactive discharges from the nuclear industry. Yet, on average, only about 0.1% of the average person's exposure is due to this practice. The majority (according to current estimates(1) somewhat less than 90%) of the average person's exposure is received from natural radiation sources, the remainder being largely due to medical procedures and fallout from weapons tests. The relative magnitude of exposures from natural radiation sources has been used, some might say over-used, by the nuclear industry in an attempt to try to allay public anxiety about radioactive waste discharges and, indeed, they do provide some sense of perspective. But their relative magnitude and, in some cases, extreme variability, justify a deeper consideration of them than merely for the purpose of developing information to support the use of nuclear energy.

It is assumed in radiological protection that any exposure to radiation might cause harm to the exposed person or his descendants. This assumption should apply to exposures from sources of both artificial and natural origin; there is, after all, no intrinsic difference between the radiations emitted by them and their biological effects. Indeed, it is this fact that makes the comparison of exposures from natural and artificial sources valid. Yet, in sharp contrast to the strict controls over exposure to artificial radiation sources, relatively little attention has been given to the control of exposures due to natural radiation sources. There are various reasons for this; an innate feeling that what is natural is without harm or, at least, acceptable; a lack of recognition that exposures may be controllable; and, undoubtedly, a lack of public concern about them.

It is definitely not the purpose of this paper to create public anxiety about natural radiation exposures but rather to point out that there are circumstances where exposures could, and probably should, be reduced. This is particularly so in the case of indoor exposure to radon decay products, which is the subject of this paper.

SOURCES AND EXPOSURES

Apart from radon decay products, sources of exposure to natural radiation include cosmic rays, terrestrial gamma rays and radioactive material in the body. The National Radiological Protection Board routinely assembles and analyses data on all sources of human exposure to ionising radiation in the UK. A summary of the data from the latest review(1) is given in Table 1; doses from both natural and artificial sources are given. The dose quantity employed is the effective dose equivalent, which provides a common index of risk for uniform and non-uniform irradiation of the body; it is expressed in sieverts, symbol Sv. The unit used in Table 1 is microsivert, μSv, which is a millionth of a sievert.

The values for terrestrial gamma rays and for radon and thoron decay products are currently under review and may be revised in the near future. Nevertheless, the table reveals that radon decay products are the single most important source of exposure of the UK population.

ORIGIN OF RADON

Radon is a gaseous radioactive element with many isotopes. Two of consequence occur in nature, radon-220 and radon-222. The first isotope, radon-220, is known as thoron because it occurs in the thorium decay series. The second, radon-222, which is commonly called radon, occurs in the main uranium series. It is considerably more important than thoron in radiological protection because of its longer half-life. Attention here is therefore directed to radon-222 and its common name is used.

Uranium is widely dispersed in the earth's crust at low concentrations. Uranium-238 is the head of the main decay series and its best-known decay product is radium-226, the immediate precursor of radon-222. The amount of radium in earth materials is therefore the direct determinant of the amount of radon generated by them. Since masonry building materials are extracted from the earth, their radium content reflects their origin.

When radon is generated in porous media such as rock and soil or brick and concrete, some enters the pores. Being a gas, radon can move through a medium of this nature, and some is exhaled at the surface. When it is exhaled from the ground out of doors, it is dispersed in the atmosphere, and its concentration in air is low. If radon enters a dwelling, either from the ground on which it is built or from the building elements, the concentration increases because dispersion is restricted by the limited ventilation. In underground mines also radon levels are higher for the same reason but attention here is confined to the indoor environment.

RADON DECAY PRODUCTS

The immediate decay products of radon-222 are radioactive isotopes of solid elements and have short half-lives. The decay chain is shown in Figure 1. On inhalation, the decay products may become lodged in the lung and the effective dose equivalent received is almost two orders of magnitude greater than that from the radon gas alone from which they were produced. It is therefore acceptable to narrow attention to the decay products. Two of the decay products emit beta particles and gamma rays and two emit alpha particles. The alpha radiation is, however, responsible for most of the radiologically significant dose.

The concentration of radon decay products in indoor air is determined by the radon gas concentration, the ventilation rate and the rate of removal of the decay products to surfaces. Since radon concentrations are higher indoors than outdoors and, on average, only 10% of a person's time is spent outdoors, most of the exposure from radon decay products arises indoors(2).

NATIONAL AND REGIONAL SURVEYS

Until recently, there was considerable uncertainty in the UK about the doses to members of the public from radon decay products in dwellings. In the early eighties it began to emerge that there were quite high levels of radon decay products in dwellings in one region of the country and the question was raised whether standards might be necessary to limit exposures. It was recognised at the outset that it would be imprudent to bring in controls without fully understanding existing conditions. Systematic surveys were therefore started(3), the objectives of which were:

(1) to determine the general distribution of radon concentrations in dwellings, to search for correlations between the measured levels and a number of relevant factors, and to improve the estimates of exposure of the population;
(2) to determine the magnitude of individual exposures and the likely number of dwellings in which exposures might be considered unduly high so that the need for standards could be assessed.

Gamma radiation levels were also to be measured for the sake of completeness.

The first set of objectives is being achieved by a national postal survey of about 2000 dwellings selected systematically from the UK housing stock. Gamma-ray dose rates and average radon concentrations in the living area and main bedroom are being determined and participants are asked to complete a questionnaire which will provide information on the characteristics of the house and other related matters. Radon concentrations are measured because there is no simple technique available for measuring radon decay product concentrations in a postal survey. Information from the questionnaires and other studies will be used to convert the measurements into radon decay product exposures.

The second set of objectives is being achieved by surveys in places expected to yield above average levels. Areas of interest were selected by reviewing information on uranium mineralisation, the reason being that the ground rather than the building materials is the major source of radon in single-family dwellings. Contact with members of the public is initially established with the help of the local Environmental Health Officers(4).

INDOOR RADON LEVELS

Although the surveys themselves have now virtually finished, a full analysis of the data has yet to be carried out and only provisional results can be given here. A summary of the latest results at present available from the national survey is given in Table 2. To give some feel for the general variations in levels throughout the UK the national survey data have been examined for regional differences and the results are included in the table.

In some cases the sample size is quite small and this limits the accuracy of the estimates of the means. Thus all that can be said about the levels recorded for Edinburgh, Cardiff and Belfast is that they do not differ greatly from the national average. The sample sizes for London, south-west England and eastern England are more substantial and the differences in levels are statistically significant. Thus the radon concentratios in London are on average about half the national average values, in eastern England about equal to them and in south-west England about three times higher. These differences are largely a reflection of the differences in local geology. London clay is fairly low in uranium and relatively impermeable to the movement of radon through the ground. The chalks and glacial deposits in eastern England, though relatively low in uranium, are fairly permeable and the granites and neighbouring rocks of south-west England are both relatively high in uranium and fractured.

The results for Aberdeen, although few in number, are interesting. For many years, radiation levels in this city have been considered to be some of the highest in the UK and therefore extensively used for the purpose of comparison with those resulting from the operation of nuclear facilities. Although not given in the table, the results from the survey show that the gamma-ray dose rates are indeed somewhat above the national values, being, on average, about 40% higher. This is due to the extensive use of granite as a building material. The results in the table, however, show the radon levels are, if anything, below the averages for the UK. The reasons for this are as yet unclear but several possible causes are cited; low permeability of the granite and sealing of the solum combined with good underfloor ventilation.

The provisional results from the surveys in those areas expected to yield above average levels are given in Table 3. Although referred to by the regions in which they occur, these areas are only parts of those regions as a whole. The results given are those obtained during visits to the houses. The full results of follow-up measurements over long time periods are not yet available but will provide better estimates of exposures. At this stage, however, it can be said that the average concentration in the houses in Cornwall that were studied is more than an order of magnitude above the national average level. The levels in the houses in Devon and the Central Uplands are also significantly higher.

The spread of values in these areas is of greater interest than the actual means. The frequency distribution of the data for the areas of Cornwall studied is shown in histogram form in figure 2 along with the UK data from the national survey for comparison purposes. The results show that the levels in some dwellings in Cornwall are more than two orders of magnitude above the national average.

RADON EXPOSURES AND RISKS

A number of assumptions are required to convert radon concentrations into annual effective dose equivalents from radon decay products but these will not be discussed here. Suffice it to say that an average indoor radon concentration of 1 Bq m^{-3} is currently considered to result in an annual effective dose equivalent of about 20 μSv(5). This conversion factor was used to derive the values given in Table 4. Confirmation of the lower mean exposure to radon decay products than the value given in Table 1 will need to await the final set of results from the national study. Nevertheless, at this stage, the following fairly firm conclusions can be drawn. For the inhabitants of the vast majority of dwellings in the UK, the annual effective dose equivalent from radon decay products does not exceed 2400 μSv. However, in the areas of Cornwall studied, the dose in almost 5% of the dwellings exceeds 25,000 μSv and in 1% 50,000 μSv.

There is no direct epidemiological evidence that exposure to natural radiation in dwellings causes harm to human beings. The risk factors used to calculate the risks from these levels to human beings. The risk factors used to calculate the risks from these levels of exposure have been obtained from epidemiological studies of various groups such as the survivors of the Horishima and Nagasaki atomic bombings and early uranium miners exposed to radon decay products. The basic assumption is made that the risk factors (health consequence per unit radiation dose) are constant irrespective of dose or dose rate. The overall risk factor for fatal cancers and serious hereditary defects currently recommended by the International Commission on Radiological Protection(6) is 1.65×10^{-2} Sv^{-1} (or 1 in 60 per Sv). This risk factor can be used to calculate the risk of lung cancer from exposure to radon decay products.

This risk factor applied to a simple model of latency and tumour expression can be used to compute the lifetime risk of lung cancer from radon decay products(7). The lifetime risks of premature death for a range of annual doses from radon decay products are given in Table 5: risks of death from other causes are included for comparison. It can be seen, for example, that the lifetime risk of lung cancer from an annual effective dose equivalent of 5000 μSv is 4×10^{-3} (or 1 in 250), which is about 2% of the overall risk of fatal malignancy facing the average individual or about 0.4% of the risk of death from all causes.

REMEDIES AND PREVENTION

The concentrations of radon and its decay products can be reduced by increasing the ventilation. A simple measure such as the removal of weather-stripping may be sufficient where high radon levels are caused by unusually low ventilation rates. In other cases, electric fans might be installed to increase ventilation, at least as a temporary measure. There is however a penalty to be paid in energy consumption, and it is doubtful whether occupants would be prepared to use such methods on a long-term basis. Ventilation can also be increased in a controllable fashion by mechanical ventilation with heat recovery. Such devices are relatively expensive to install, and it is unlikely that they would find wide-scale application in the UK. In addition, they are likely to be of value only when high radon levels are primarily caused by low ventilation.

Electrostatic precipitators or other devices for aerosol filtration could also be used to reduce the concentration of radon products. The capital and running costs would be substantially lower than advanced mechanical ventilation systems. The biggest problem with this technique, as with extractor fans, is that they are active rather than passive and can be regarded only as temporary measures.

Experience, particularly in Sweden, demonstrates that the caulking of apertures in the floor slab can be highly effective in reducing radon ingress and can be carried out at low cost(8). The use of a barrier to the convective flow of soil gas through cracks in the slab has also been successful in a UK dwelling(9). These passive methods have the advantage that little or no maintenance is required and the occupant does not need to be continuously aware of the radon problem.

Work in the UK(9) and Sweden(10) also demonstrates that mechanical devices to remove radon from the underfloor space are very effective and can be installed at modest cost. These devices, usually fans, suffer again from the disadvantage that occasional maintenance is required and the occupant must be prepared to operate them.

Some of these remedial techniques could also be adopted as preventive measures during the construction of new dwellings on sites that would otherwise cause high exposure indoors. It would, in fact, be considerably easier to use appropriate barriers to prevent or reduce substantially the radon that might enter new dwellings from the ground than to remedy existing dwellings on the same site. Modest changes to present design and construction practices are likely to be sufficient to minimise or virtually eliminate discontinuities in the structural membrane separating the dwelling space from the ground underneath.

PROTECTION STANDARDS

The mean dose to the UK population of 430 µSv in a year (Table 4) implies a hypothetical annual rate of death of about 400 per year if the usual assumptions are made that all doses have an associated risk. In the short term, there is little that can be done to reduce this. In the longer term, consideration might be given to the establishing of design standards for future dwellings that would limit radon ingress from the ground.

At the present time, the main objective of any control policy must be to prevent individuals from receiving too high doses. Members of staff of the National Radiological Protection Board put forward suggestions regarding the limitation of dose(11). A distinction was made between existing dwellings, for which action would be remedial, and new dwellings, for which prevention could be incorporated at the design and construction stages. The suggestions were that there should be an action level of 25,000 µSv a year for existing dwellings and a design level of 10,000 µSv a year for new dwellings.

There is no absolute justification for these levels. The action level of 25,000 µSv a year for instance was considered appropriate since continuous exposure at this level implies an increase approaching 10% in the lifetime risk of contracting fatal cancer and an average risk of death comparable to that from all common accidents combined. Some might suggest lower action levels but it must be remembered that the lower the level, the larger will be the size of the problem and the overall cost to the country. The estimated maximum number of dwellings that might be affected by an action level of 25,000 µSv a year is about two thousand; at 5,000 µSv a year, the number would be about fifty times higher. Furthermore, the law of diminishing returns applies; as the action level is lowered, so the cost per unit dose saved will increase.

The suggestions by members of NRPB staff were considered by the Royal Commission on Environmental Pollution(12). The recommendations of the RCEP given in its tenth report, which was published last year, are reproduced in full here.

1. Priority should be given to devising effective remedial measures for those existing houses where radon concentrations are such as to cause anxiety, and to devising preventive measures for new houses.
2. Remedial action should be undertaken on existing dwellings, initially on those where the annual effective dose equivalent exceeds 25 mSv (25,000 µSv).
3. A design limit should be applied to new dwellings. On the basis of information available to us we favour an annual effective dose equivalent limit of 5 mSv (5000 uSv), but a decision on the value should await the assessment of recommendations in the forthcoming report on controllable sources of radiation by the International Commission on Radiological Protection.

Since the RCEP report, the ICRP recommendations have been published(13) and, although there are some differences, largely of emphasis, they are broadly in line with the NRPB staff suggestions.

That is essentially where the position on the development of standards rests at the present time. Before the NRPB, as part of its statutory functions, can offer formal advice to Government, the full and considered results of the surveys of radon in dwellings and the studies of remedial and preventive techniques are required. It is expected that this information will become available by about the end of 1985.

IMPLEMENTATION

There is much less concern and hence less interest in radiation exposures of natural origin than of artificial origin and unless some public awareness of the significance of indoor exposure is generated, it is possible that any action to deal with the problem will be misunderstood. It is necessary therefore to develop a systematic approach to public education about radon in dwellings. The aims of a programme of information should be to indicate that there is some risk from radon decay products, that measures are feasible to reduce the risk, that the problem is not acute even for high levels, but that action is required without undue delay. To this end, the NRPB has deliberately followed a policy of providing full information on the national and regional survey work and on the remedial studies. This information has been widely reported in the media, and further material will be released as the data are being analysed. But dissemination of information on potential health hazards is not without its own risks as it can lead to undue public anxiety or the accusation that one is merely playing upon human fears.

The procedure for implementing standards has yet to be determined in the UK, and no decision has been taken as to whether statutory regulations or administrative procedures should be used: indeed a combination of both may be most appropriate. This is a matter for the appropriate Government department rather than NRPB, but it is as well to recognise that there are considerable difficulties in effecting controls over the environment in existing dwellings.

For new dwellings, the situation is, in principle, more straightforward. Building regulations apply to the construction of dwellings, and it would seem that, if they were deemed appropriate, they could be used to avoid a hitherto unrecognised hazard. Since radon levels in dwellings are affected by the type of floor or the use of radon barriers in the floor, and since these are matters that could readily be inspected, implementation should not pose serious problems.

Whatever procedure is used for implementing standards, it will be necessary to establish methods for discovering dwellings with high radon levels. Systematic measurements will need to be mounted in all likely dwellings in areas expected to yield high results using simple inexpensive monitoring techniques. The detection of suspect building sites would need to be based on an assessment of geological information, such as the type of ground and its permeability, and a study of the results of any previous surveys of radon levels in dwellings in the vicinity.

CONCLUSION

Some risks of everyday life, such as those from driving and flying, are obvious; others, such as those from smoking, can only be inferred from statistical information. The absence of direct epidemiological evidence linking indoor exposure to lung cancer might lead some observers to suggest that standards are unnecessary, and indeed the very thought that natural irradiation indoors may be harmful to health is unpalatable to some persons. There is no doubt, however, that adequate information already exists to establish the potential harm of radon decay products in dwellings, and that levels in some houses are sufficiently high to justify the setting of safety standards.

Work in the UK and elsewhere has shown that methods for reducing high radon levels in existing dwellings and of preventing high levels in future dwellings are feasible and can be implemented without undue cost. There is therefore no impediment to the production of standards on this count. Members of staff of the NRPB have already made suggestions about dose levels in dwellings, the aim being to limit the risks to occupants, and these have been broadly endorsed by the RCEP. These suggestions are also broadly in line with those made more recently by the ICRP.

The approach to formal standards in the UK is being undertaken deliberately and systematically. The results of the national and regional surveys of indoor radon levels have still to be fully analysed and assimilated, and some further work needs to be done on remedial and preventive measures. An efficient means of detecting building sites, which might subsequently cause high indoor levels if precautions were not taken during construction, is still to be devised. These are the radiological considerations on which the NRPB will offer formal advice to government in due course.

On the administrative side, procedures need to be developed for the efficient implementation of standards. Decisions have to be made on the degree of regulation required, and the lines of responsibility will need to be clear. There is also a need to increase public awareness of the matter in a way that does not cause distress or confusion but will facilitate the implementation of the standards.

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Table 1

Annual average effective dose equivalents to the UK population*

Source	Annual Dose, μSv	Per cent‡ of total
Natural		
Cosmic rays	300	14
Terrestrial gamma rays	400	19
Internal irradiation	370	17
Radon decay products	700	32
Thoron decay products	100	5
Artificial		
Medical procedures	250	11.5
Fallout from weapons	10	0.5
Occupational practices	9	0.4
Radioactive waste disposal	2	0.1
Miscellaneous	11	0.5
Total	2150	100

* Values from the 1984 review(1). Those for terrestrial gamma rays and radon and thoron decay products may be revised in the near future.

‡ Values rounded for ease of assimilation.

Table 2

Radon Levels in UK Dwellings from the National Survey

Region	Number of dwellings	Mean radon concentration ($Bq\ m^{-3}$)	
		Living area	Bedroom
UK	2000	28	20
London	123	13	11
Edinburgh	7	16	13
Cardiff	10	35	20
Belfast	3	12	9
South-west England*	50	80	63
Eastern England$^+$	95	26	18
Aberdeen	9	18	10

* Cornwall and Devon

$^+$ Norfolk and Suffolk

Table 3

Radon Levels in the Living Rooms of Dwellings in Selected Areas

Selected areas of	Number of dwellings	Mean radon concentration ($Bq\ m^{-3}$)
Cornwall	329	390
Devon	150	210
Swansea	7	14
Central uplands*	150	180
Scotland+	170	42

* Derbyshire and Yorkshire

+ Dumfries and Galloway, Grampian and Highland regions

Table 4

Annual Effective Dose Equivalents in UK Dwellings from Radon Decay Products*

	Annual effective dose equivalent (μSv)	
	UK	Cornwall
Arithmetic Mean	430	6,600
Geometric Mean	250	3,400
95% fractile	1200	22,000
99% fractile	2400	50,000

* Provisional data.

Table 5

Lifetime risks of premature death from various causes including lung cancer from radon decay products

Cause*	Lifetime risk	
All malignant neoplasms	2×10^{-1}	(1 in 5)
Lung cancer from 100,000 μSv a year	7×10^{-2}	(1 in 14)
Lung cancer from 10 cigarettes a day	6×10^{-2}	(1 in 17)
Lung cancer from 50,000 μSv a year	4×10^{-2}	(1 in 25)
Lung cancer from 25,000 μSv a year	2×10^{-2}	(1 in 50)
Accidents in the home	9×10^{-3}	(1 in 110)
Accidents on the road	8×10^{-3}	(1 in 125)
Lung cancer from 5,000 μSv a year	4×10^{-3}	(1 in 250)
Accidents to men at work	2×10^{-3}	(1 in 500)
Cancer from average public exposure to nuclear waste (2 μSv a year)	1×10^{-6}	(1 in 1,000,000)

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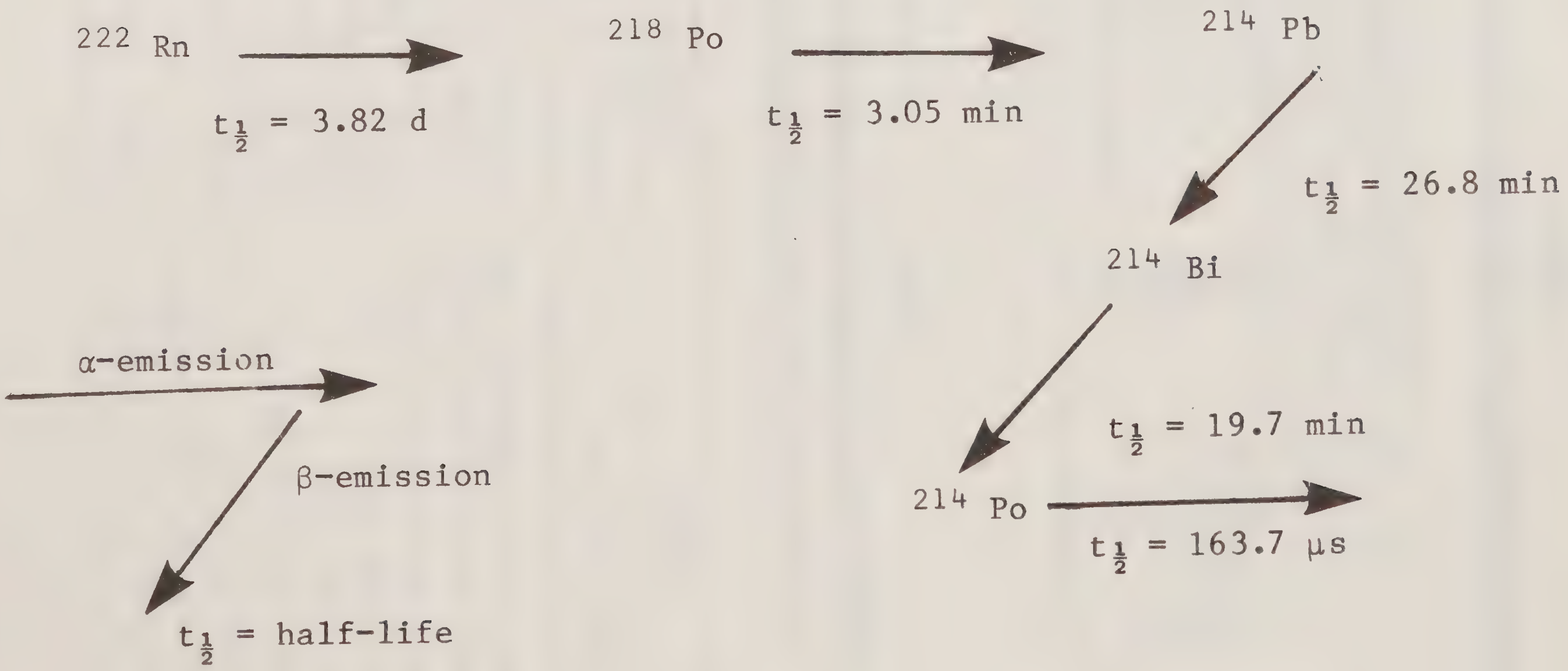
* The radiation units here refer to the effective dose equivalent.

Figure 1. The immediate decay products of radon-222



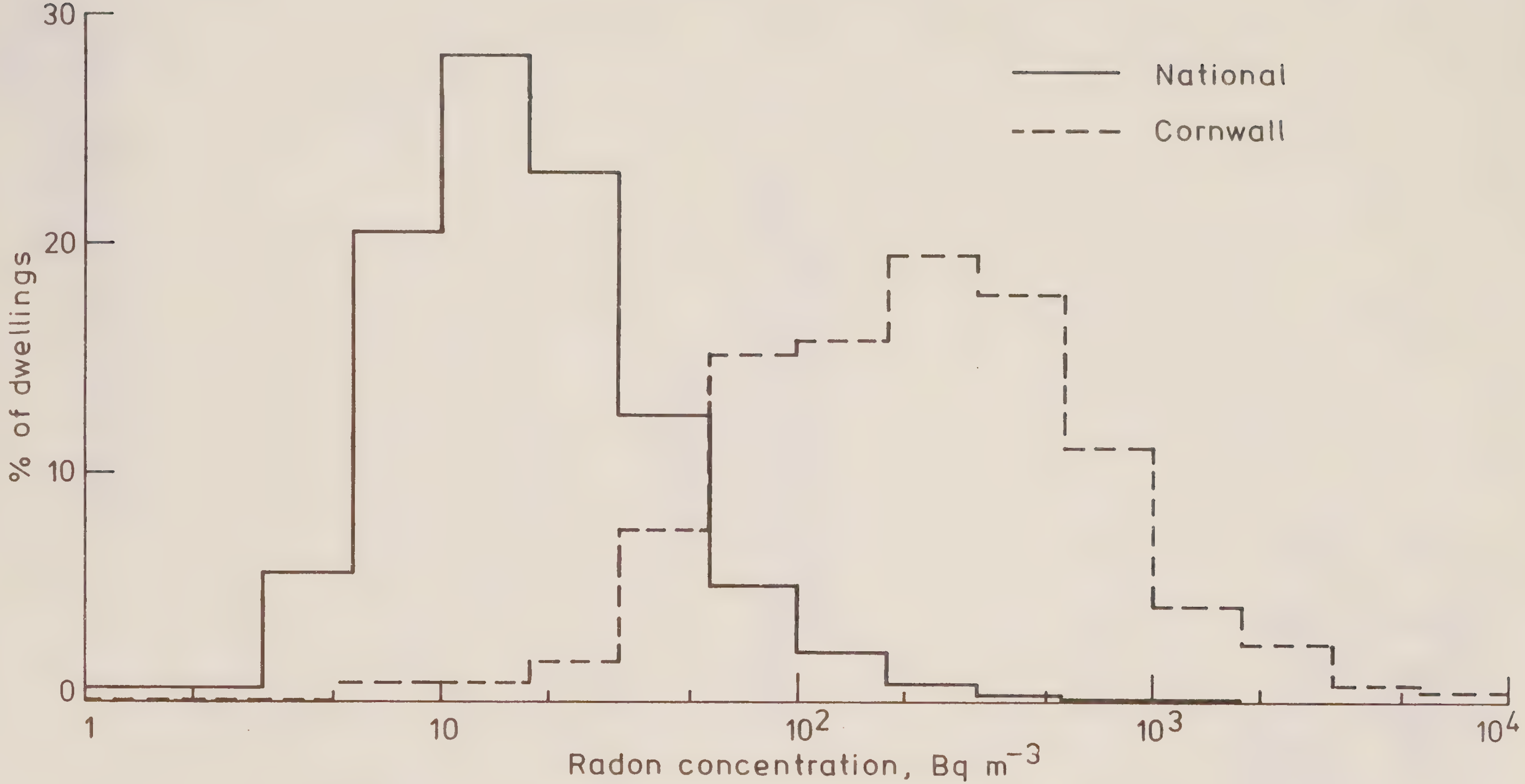


Figure 2 Frequency distribution of radon concentration in air in the living areas of some UK dwellings

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– INDOOR AIR POLLUTION – ASBESTOS REMOVAL PROCEDURES

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INTRODUCTION

This paper deals with when and how to remove asbestos from buildings and dispose of it. It is divided into ten sections, as follows:

Is the undisturbed asbestos causing a hazard?
To strip, encapsulate, or leave well alone.
Dry versus wet stripping.
The enclosure of the work area, and the air lock.
Negative pressure systems.
Checking that all is well when asbestos work starts.
Protection of the asbestos operatives.
Vacuum cleaning asbestos.
Waste disposal.
Preparing a specification and choosing and working with a contractor.

Useful sources of information on asbestos are given at the end of the paper.

IS THE UNDISTURBED ASBESTOS CAUSING A HAZARD?

It has been repeatedly stressed that, 'There is no safe limit of asbestos exposure'. This statement should be placed alongside others, such as 'There is no safe limit to the number of:- stairs you climb / times you have a bath / rides you have on a train', etc.

Technically, the statement on asbestos means that if you plot asbestos exposure against incidence of asbestos related diseases, the line or lines appear to pass through zero.

Various scales have been proposed to provide a priority list for action. My personal view is that if fibre counts taken during normal occupation show levels of 0.01 f/ml. or less, take NO action - unless building or other works require the material to be disturbed.

'Fibre counting' is a skilled procedure carried out by a trained analyst to ascertain if the air being breathed contains an excess of the fine fibres which gain access to the lung. The method used must conform to the standards laid down in the HSE Guidance Note EH10, recently re-issued. The local HSE can provide the names of Laboratories which can carry out this work; they must be in Category 1 or 2 of the R.I.C.E. scheme.

The procedure involved requires a specified volume of the air under test to be sucked through a membrane filter, and subsequently viewed under a microscope, when trapped fibres are counted. Asbestos fibres are not identifiable as such by this method; in practice ALL fibres in the appropriate size range are counted. In certain circumstances more sophisticated methods will have to be used to eliminate the non-asbestos fibres from the count.

The present evidence is that the chance of suffering from an asbestos related disease is negligible when compared with other everyday risks (unless you work or have worked in a manufacturing industry involving asbestos, or in the asbestos stripping and associated industries).

TO STRIP, ENCAPSULATE, OR LEAVE WELL ALONE

Asbestos containing materials and insulation receive attention for many reasons:-

1) The material is giving off, or is likely to give off, significant fibre release in the life of the building or plant.
2) It is policy progressively to remove all asbestos containing materials, irrespective of the safety hazard. This can, in some instances, be shown to be financially sound when resale value is taken into account.
3) Public relations or political pressure may suggest action, even if no benefit, in terms of safety, results.

In many cases recently, because of the asbestos scare, considerable sums of money have been expended where no fibre count could be detected before corrective action was taken.

To quote Dr. John Cullen, HSC chairman of the committee considering asbestos Regulations, 'Our view on asbestos in buildings is simple. If the material is damaged or has deteriorated it should be dealt with - either sealing or removal. If the material is undamaged, by and large it should be left alone. Stripping undamaged asbestos material may well introduce a risk where none existed before - a significant risk for those engaged in the work and, quite possibly, a residual risk for the occupants after removal.'

DRY VERSUS WET STRIPPING OF ASBESTOS

For many years, asbestos was stripped wet, i.e. the material was injected with water, sometimes with added surfactant, before being handled. Where this is possible without undesirable side effects, this undoubtedly reduces the fibre count in the work area, but:-

1) It takes skill and time to ensure that the water soaks in effectively without running out and producing an asbestos slurry. A half imprenated lump of asbestos will release almost as many fibres as the original dry material.

2) All drips etc. from the operation must be contained by placing polythene sheeting, or similar material underneath the work, and this with the water and mud must be removed BEFORE it dries out. The final decontamination of the work area must then wait until the whole is totally dry. This also takes time.

3) Given the proper enclosure of the work area (still required for wet stripping) and where practicable, negative pressure on the tent, dry stripping is usually quicker and cheaper, but the fibre count in the work area will be much higher. However modern respiratory equipment is vastly more effective than a few years ago when wet stripping was in vogue.

4) Whether wet or dry is adopted, the end result, namely no hazardous fibre release during or after the work, should be the same.

5) It should be remembered that however thorough the cleaning off of asbestos from the base metal etc. some fibres will remain on the 'cleaned' surfaces. It is usual therefore to seal these in, using an unpigmented PVA spray or similar material.

THE ENCLOSURE OF THE WORK AREA, & THE AIR LOCK

The area in which asbestos work is to be carried out is termed the 'protected area', and only authorised persons wearing appropriate protective clothing may enter.

The area may not be an enclosure, but it usually is. An example of a protected area without an enclosure is an area cordoned off after an accident involving asbestos, say in a works. Fibre counting is used to determine the extent of the cordoned off zone, which will have warning signs at regular intervals to keep out unprotected personnel. An enclosure may, of course, be erected subsequently as part of the clean up operation.

When the area is an enclosure, which is the normal circumstance, the following points need consideration:-

1) When the work is complete, the enclosure must be removed without releasing asbestos fibres, so it needs to be cleanable and have no dust traps.

2) It must be as dust tight as possible, and will probably be tested using smoke, before use.

3) It must have its entrance/exit, which is usually an air lock, in a position which will reduce the distance to the Hygiene Unit to the minimum and give access to the disposal skip or other facility for collecting contaminated waste.

4) If there will be plant inside the enclosure which requires air to operate it, eg a live boiler, then a separate dust tight duct will have to be made to feed

the air from outside the tent. Motors etc with cooling fans will have to be shut down if they cannot be decontaminated after the asbestos work.

5) The enclosure must be strong enough to withstand the negative pressure from the extract unit, and if outside, the effects of sun, wind, rain and snow. Larger enclosures will be quite complicated structures.

6) If scaffolding is used, the tubes, boards, and fittings should be outside the tent if this is possible, for decontamination reasons. Tubes inside the enclosure must have their ends sealed to stop asbestos getting inside.

7) If the area to be enclosed is large enough, it is sometimes beneficial to sub-divide the work space into smaller sections. Care is needed in this situation to avoid creating un-treated surfaces at the intersections.

8) If there is a danger of the enclosure being damaged, either accidentally or by vandals, extra protection in the form of plywood, or similar material, may be needed.

9) Watch out for false ceilings, and other features where the walls do not go up to the true ceiling.

Before erecting the enclosure:-

1) All loose fittings must be removed, together with all movable equipment. If there is any possibility that these are contaminated, they must be cleaned first with an asbestos type vacuum cleaner.

2) The floor will also need vacuuming, and covering as well with polythene or similar material if it is not totally impervious, eg grano finish etc.

3) All fixed items that cannot be easily cleaned should be sealed in dust tight sheeting.

4) If the work is to be carried out from a scaffold floor of planks, these should be covered with two layers of heavy gauge polythene, with the joints sealed, followed

by a working surface of hardboard or plywood, again with the joints sealed. The tent walls are then sealed to the hardboard, etc. This procedure ensures that the scaffold planks remain uncontaminated.

The enclosure construction

The simplest enclosure uses the walls and ceiling or roof of the room or building. All doors, windows, ventilating ducts, cable and pipe entries need careful sealing. Wooden floors are not airtight, so need covering to avoid fibre leakage, apart from the boards themselves not being impervious. The air lock will normally be constructed in a doorway.

The 'air lock' is not a magic trap that stops all fibres from getting from the working area to the clean world outside. Its chief purpose is to provide buffering to keep fibre laden air in the inner section from the outer section.

The air lock usually comprises three sections. Each section is connected to the next by a door, normally formed by two polythene sheets, each about one third the width of the doorway, sealed to the top and the two sides of the doorway. On the work side of these sheets is hung a third sheet, the full width of the opening; this sheet is only fastened at the top. Four such 'doors' are needed, one between the work zone and the air lock, two inside the air lock, and one at the outside entrance.

If large items have to be carried through the air lock, such as wrapped and sealed asbestos boards, the sections of the air lock will each have to be large enough to accommodate the item and the men carrying it. In these circumstances, the operators inside the enclosure will leave the cleaned wrapped items in the centre compartment, and others, appropriately clad, will remove the parcels to the disposal container.

When negative pressure is in use the full width flaps in the airlock will be pulled towards the dirty end, due to the air passing through the 'lock'. This is the ideal situation, as the air lock will be purged with clean air from outside the tent, continuously.

If framing has to be used for the enclosure, remember that it has to be decontaminated before fibre counting is started, at the end of the job. It is best if the frame is outside the contaminated structure. This is possible by fixing the sheeting around the outside, and subsequently covering the framework by sealing polythene over it, inside.

Many methods are used to seal the edges of the polythene etc. the most popular being adhesive tape. Vinyl or PVC tape is only suitable for short term sealing as the adhesive allows the tape to 'creep'. Better is a fabric tape, or heat sealing, but the operators have to be skilled in the use of the heat sealer as it is easy to get under or over-cured seals.

Used on their own, staples or battens held in place with nails are unsuitable for all except the very low fibre release jobs, or small tents.

Dismantling the enclosure

When the work area has been 'passed' by having fibre counts taken and approved, the enclosure can be removed. All sheeting is usually disposed of as contaminated even though it has been spray sealed as part of the decontamination process. If the structure has been protected by being enclosed in its own sheeting, then this is re-usable.

NEGATIVE PRESSURE SYSTEMS

The fibre laden air in the working enclosure must not leak out, or there will be a fibre count that is unacceptable, outside. Filtered air extraction is used to ensure that there is no outward leakage, ie there is a 'negative pressure' on the enclosure.

If the enclosure is in the open air, in an area well away from where the public have any access (certain demolition conditions, tank farms, etc.), there may be no need to keep the work area under negative pressure, but this is becoming more and more the exception.

Negative pressure is present when any damage or leak in ANY part of the enclosure results in the air outside being sucked into the work zone. Just because air is being extracted by a so called 'air mover', it does not mean that the tent is under negative pressure.

To provide negative pressure and air extractor of sufficient power and volume has its inlet sealed into the enclosure wall. The air is filtered by special high efficiency filters before entering the extractor, so that (for practical purposes) no fibres can get through. The air volume needed and the suction capability of the fan will depend more on the leakages in the tent, and the length of any discharge ducting required, than the size of the enclosure.

Generally the HSE prefer the air from filtered air extraction equipment to be discharged outside the building. This is because many devices in the past, and unfortunately a number still do not live up to the claims of the manufacturers or agents.

The HSE view is that if fibres are present in the discharged air (and there should not be any in a well designed system, properly maintained), the concentration could build up if the air is released into the building. However, discharging air outside brings its own problems, and the following points need watching:-

1) Has the fan a high enough suction capacity to extract air from the enclosure against the back pressure of the filters, the ducting, and a strong wind blowing on the discharge outlet? Very few models are adequate in this respect; a minimum static pressure of three inches water gauge or 750 Pa. will be needed, and much more if the duct is long.

2) Is there an effective non-return valve in the system, so that should the fan stop, the wind will not pressurise the tent?

As a general guide do not trust a filtered air extractor unless:-

1) The outside of the HEPA (high efficiency particulate arrestor) filter, also called the 'absolute filter', is visible and the whole filter is outside the enclosure.

2) The unit has one or more pre-filters, and these can be replaced from INSIDE the enclosure without affecting the HEPA filter, which should be protected from damage by suitable guards.

3) The inlet end can be totally sealed with a strong cover to contain the dirty filters when the job is finished. Filters should not have to be taken out at the end of the asbestos decontamination process, as this operation will in itself create a fibre count.

Under the 1969 Act, this equipment has to be inspected every seven days and a record kept. In addition every fourteen months it has to be tested and examined by a competent person. This implies the need for a decontamination workshop in which fitters can work under asbestos conditions.

Finally, be on your guard if hired equipment is in use. Find out how the hirer ensures that the device is safe to handle, and if he has the type of workshop referred to above to carry out maintenance. If the hire company requires the device to be decontaminated before being returned to him, the chances are that the effectiveness of the machine relies upon the skill of the last user, and not the hire company.

CHECKING THAT ALL IS WELL WHEN ASBESTOS WORK STARTS

There will be many contracts involving work with asbestos where, after the enclosure is complete and the negative pressure system operating, it will be obvious that no outward leak of fibres will be possible because the tent walls will be visibly sucked inwards as well as the flaps in the air lock. In these circumstances there is little object in smoke testing the enclosure. However look out for ducting passing through the tent which is connected to the suction side of air conditioning or ventilating systems. These may have a greater depression on them than that on the enclosure. In such cases smoke testing is essential.

Although the enclosure may not leak fibres, there are other sources to be checked by monitoring:-

1) Are the operators causing measurable fibre release as they carry out contaminated material in their sealed bags through the air lock?

2) Are they releasing fibres when they come out of the air lock at the end of their shifts?

3) Is the negative pressure device and its filtering system maintaining a clean discharge?

4) Normally the enclosure will have a substantial fibre count inside for some time after work on the shift has finished. Ideally the negative pressure should operate from the start of the work until decontamination is complete and the area is ready for fibre counts. In critical situations standby negative pressure systems with automatic start up will be needed; make sure that non-return valves are fitted to the outlets in these circumstances.

PROTECTION OF THE ASBESTOS OPERATIVES

All work with asbestos coatings and asbestos insulation (which includes encapsulation) has to be carried out without hazarding the public or those doing the work. For most jobs, as well as enclosing the work area, this will necessitate the use of special protective clothing and respirators.

The methods of changing into and out of this clothing must ensure that the asbestos fibres are not taken out into the public areas, or home on the operators' personal clothing.

The detail procedures vary, and will not be considered here, but the fundamentals are as follows:-

Protective clothing

Normally, ALL personal clothing, including underclothing, is removed before donning respirators and protective clothing.

For most work, disposable overalls are unsuitable, and hooded coveralls of a distinctive colour, with elasticated cuffs and no pockets, are worn. Footwear is often wellington boots, worn with the coverall legs outside the boots. ALL underwear worn in the work area becomes protective clothing and must not be taken home by the operatives.

All protective clothing has to be specially laundered where facilities for an asbestos service exists. Sealed soluble bags are used to transfer the dirty clothes to the laundry. An ordinary laundry must not handle asbestos.

Respirators

The HSE issue annually an approved list of suitable respirators for work with asbestos (F2486). This list should be treated with caution, as the protection quoted is theoretical. In practice, the highest protection should be used, except where it is known that the fibre release will be minimal.

The type of respirator most used in asbestos stripping work is the battery powered high efficiency positive pressure equipment with full facemask. Inflated blouses, often called 'space suits' by the lay public, are not of necessity the first choice.

Note that the face mask of the respirator is worn under the protective clothing hood, and is put on before the clothing.

Hygiene, or Decontamination Facilities

When an operator has been working with asbestos, his personal decontamination takes place in two stages.

The first is in the enclosure 'air lock', where the clothing will be thoroughly vacuumed. It will then be removed in the inner section of the 'lock' and left for future use, or bagged for laundering.

If the shower unit is not immediately alongside, the operator will put on clean 'transit' overalls to allow him to get to the hygiene unit, where the second stage takes place. He will normally still wear his respirator until he is about to shower.

The hygiene unit will comprise three sections, with through ventilation to stop asbestos contaminating the clean section. The terms used, namely 'clean', 'shower' and 'dirty' are self explanatory, except that the 'dirty' end has to be kept clean, even though from time to time there will be some release of fibres when the operators pass through.

Personal clothing is only allowed in the 'clean' compartment.

The electrical power supply needed for some of these units can present a problem, as only one electric shower takes 30 amps current. Proper electrical protection is essential, with residual current earth leakage circuit breakers being mandatory. Gas heated units are available, but these still need an electrical supply, usually 13 amps.

Note that the 'dirty' water from the showers will contain a minute amount of asbestos fibre. To my knowledge no Water Authority has any objection to its discharge direct to their foul drains.

VACUUM CLEANING ASBESTOS

Vacuum cleaners are needed in work with asbestos for:-

1) Cleaning any contamination off equipment in the area to be worked in before taking it away to be stored while work is in progress.
2) Cleaning down protective clothing and respirators prior to leaving the work area.
3) Providing a negative pressure in very small enclosures.
4) The removal of as much loose fibre as possible after work is completed as part of the final decontamination process.

Special vacuum cleaners are employed for this work. Until recently standard industrial cleaners fitted with an 'after filter' of the HEPA type were used but there is now a British Standard 5415 which embodies a number of safeguards including a label showing that the equipment contains a hazardous dust.

These special vacuum cleaners in common with their industrial counterparts are unable to operate with long lengths of suction hose. The cleaners therefore have of necessity to be taken into the work area, where they get contaminated. Few designers have studied the needs of the asbestos removal industry with a view to producing a vacuum cleaner that can be easily decontaminated, and this remains a problem.

Emptying the machine when the collection bag is full

When the cleaner has collected the asbestos material in its paper bag, this has to be removed to allow a new one to be fitted, and the old bag disposed of as asbestos waste.

Note that the fine asbestos fibres that are injurious to health, will pass without difficulty through the paper bag material. So the outsides of the bags are not 'clean' when used. For this reason, bag changing cannot be carried out in a clean environment, or there will be a fibre count at the end of the procedure.

When a vacuum cleaner is in use on asbestos work and the air from it is being discharged outside the work enclosure, then the 7 day inspection Regulation has to be worked to, as well as the 14 month test, exactly as for negative pressure equipment.

WASTE DISPOSAL

It is the client's responsibility to ensure that the asbestos waste arising from any work that he, or his contractor, carries out is disposed of in accordance with current legislation (at present the Control of Pollution Act 1974, and Control of Pollution 'special waste' Regulation 1980).

The appropriate paper work, which is statutory, has to be circulated to the Authorities concerned at least three working days before the waste is moved from site. This applies to even a single bag of asbestos.

In some areas the local Waste Disposal Authority will nominate the client as the producer of the waste, and the client will be responsible for originating the paper work; another Authority will nominate the contractor to be responsible. This anomaly is still to be resolved.

If skips are to be used to transport sealed waste bags, they should be of closed design, with locks or similar to prevent unauthorised persons having access to the load. The skips should carry the appropriate Hazchem sign.

It is a duty upon the producer to ensure that the driver of the vehicle removing the waste knows the hazards, how to deal with an emergency, and has appropriate protective clothing for use in that emergency.

Until recently, few disposal sites had water available to wash out a skip when it became contaminated due to broken bags etc. but this is being corrected and it will soon be a requirement that, either the vehicle carries a suitable water tank and pressure device, or that it will be available at the tip.

PREPARING A SPECIFICATION AND CHOOSING AND WORKING WITH A CONTRACTOR

The Specification

Avoid restating the COP3 Code or any other of the Regulations.

In addition to normal contract safeguards consider the following points:-

1) How will you have the work monitored, particularly if shift work is needed or asked for to meet a deadline?
2) Are you going to have fibre counts taken outside the enclosure while work is in progress?
3) What counts will you consider unacceptable, either outside the enclosure or inside when work is 'complete'?
4) Is the final fibre counting to be taken statically or with disturbance to the air in the enclosure?
5) Are you insisting on negative pressure, and what criteria will be used to determine if it is 'acceptable'?
6) If heat insulation is to be removed from live equipment can the heat build up be contained?
7) Is there a vandal problem? How is it to be met?
8) Are you sure you know the extent of the asbestos problem? Have fibres penetrated to other areas not considered to be part of the contract, such as lift shafts, service ducts, or ventilating systems?

Choosing and working with a contractor

When a Member of the Asbestos Removal Contractors

Association is employed it is important that a report be sent to the Association if the skills displayed are insufficient for the work undertaken. It is only in this way that under-performers can be weeded out from the membership. But the evidence must be able to stand up to scrutiny; a company's reputation and livelihood will be at stake.

It is not difficult to get an asbestos stripping licence, but the conditions imposed upon the licensee by the HSE have some bearing upon how the HSE views the company, so ask for a copy of the whole of the Licence Form.

Price is important, but the minimum price is not necessarily the cheapest total cost. In the case of a high quotation check to see if the contractor has detected something that a less experienced company has failed to notice.

Probably the highest priority apart from choosing the right contractor is to get the public relations properly tied up. On larger jobs, there may be a case to include in the contract the requirement to train your liaison staff in the method the contractor is intending to employ, so that he or she can explain to those able to witness the work, what to expect.

If you have no local expert, consider arranging for the contractor to train the liaison personnel in the wearing of the respirator and protective clothing so that the work progress can be inspected from inside the enclosure, or any problems encountered can be viewed firsthand.

USEFUL SOURCES OF INFORMATION ON ASBESTOS

A Guide to the Asbestos (Licensing) Regulations 1983. HSR (R) 19.

Approved Code of Practice and Guidance Note, 'Work with Asbestos Insulation and Asbestos Coating' 1985 (includes full text of Asbestos Regulations 1969)

Certificate of Approval (Respiratory Protective Equipment) Form 2486.

Asbestos Materials in Buildings. D.O.E.

Probable Asbestos Dust Concentrations at Construction Processes. EH35.

Work with Asbestos Cement. EH36.

Work with Asbestos Insulating Board. EH37.

Asbestos Control Limits, Measurements of Airborne Dust Concentrations. EH10.

All are available from H.M. Bookshops.

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ANNUAL CONFERENCE
14 – 17 OCTOBER 1985
SCARBOROUGH

52nd CONFERENCE PART TWO

Report of Discussions

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Edited by Jane Dunmore

Speakers: Dr. B. Smith, Dr. H.Viles (standing in for Dr. Butlin) and P. Burgess

MR. A. ARCHER (NSCA Vice President), opening the discussion, praised the excellence of the presentations made by all three authors. Referring specifically to Dr. Smith's paper, he said he had found it both illuminating and fascinating. As he understood it, Dr. Smith's model suggested that while reducing emissions would have little impact in terms of benefits within the UK (quite understandable in view of the UK's tall stack policy) there would be benefits in Scandinavia. However, Dr. Smith had also mentioned the expense of the exercise of reducing emissions, and Mr. Archer intended to pick up on that point later on in his remarks.

Turning to the paper by Dr. Butlin, presented by Dr. Viles, he noted the call for more research to be undertaken in the area of building damage (and indeed, Dr. Smith had made a similar plea in relation to modelling work).

Mr. Archer said that Peter Burgess had neatly presented the DOE's view of acid deposition, or perhaps the Department's interpretation of Government thinking on the subject - if the Government could be said to think deeply on any environmental issue.

Turning specifically to the arguments put forward in Peter Burgess's paper, Mr. Archer said that there was a discrepancy between his statement that a reduction in UK emissions would not produce a substantial benefit abroad and Dr. Smith's conclusion that there was proportionality between emissions and depositions at long range in the longer term.

Peter Burgess had further referred to the fact that retrofitting FGD at 12 major power stations might add between 5 and 6% to the cost of electricity to the consumer. However, Mr. Archer drew a parallel with the lead debate. The costs to the oil industry and the motor industry had been much cited until the Royal Commission on Environmental Pollution had put matters into perspective.

He did not wish to make too much of the financial implications, aware that these might tip the balance in the choice between coal fired power generation and nuclear power. But it was worth bearing in mind the point made in the 10th Report of the Royal Commission on Environmental Pollution which said that, to put the figure of 6 per cent in context, during the last 9 years the retail price of electricity had increased on average by about 4 per cent per year more than had retail prices in general.

In the Selby area of Yorkshire there were two coal fired power stations and another on the boundary with an adjoining District. Nevil Parkinson, Chief Environmental Health Officer of Selby District Council, had supplied Mr. Archer with some interesting statistics.

The largest power station, Drax, had been designed some twelve years previously and upon completion would have a capacity of some 4,000 MW; its present capacity was 2,000 MW. Waste gases were emitted from a stack 850 feet high. Upon completion, the power station would burn approximately 10 million tonnes of coal annually and would emit half a million tonnes annually of SOx/NOx; to this amount could be added another half million tonnes of discharged pollutants from the other two power stations combined.

Nevil Parkinson's own comments were simple but telling: that, whatever the arguments about the effects of acid deposition, there could be no possible reason for discharging such enormous quantities of pollutants when the technology was available to control or abate the emissions, and, in the case of Drax, there was space to install the necessary plant. The response to that point from Lord Marshall, Chairman of the CEGB, had been as follows:

> "If it is shown that acid rain is causing significant damage to the environment and if reducing sulphur emissions from power stations offers a real improvement, if it is the most cost-effective solution, we will take whatever action is necessary".

Mr. Archer described Lord Marshall's reply as somewhat negative, patronising and complacent and in conflict with the recommendations of the 10th Report of the Royal Commission on Environmental Pollution, which had stated:

> "...recognising the UK's international obligations and the technical and economic advantages of a carefully phased programme over a reasonable timescale, we recommend that the CEGB should introduce, on a pilot basis, over the next five years, certain of the sulphur abatement options that are already available. It is in our view prudent to do this, not least to gain appropriate technical experience and to encourage relevant innovations in British industry."
> (Para 5.96, page 147, Tenth Report, RCEP)

Mr. Archer summed up by saying that everybody knew that the acid deposition question was extremely complex. While he thoroughly agreed that it was necessary to have more research, not least because action based on scientific findings was always preferable, he questioned whether action had to wait for absolute proof before it could commence. He commended the NSCA policy statement on acid rain for focusing attention on the issues and being a balanced call for more positive measures to deal with the problem. He also recommended to delegates the recent publication,"'Acid rain' and London" by Dr. Laxen and Dr. Schwar of the GLC Scientific Services Branch. He said it was further proof, if more was needed, of the disastrous loss that would occur if the GLC Scientific Services Branch were to be disbanded or broken up following abolition of the GLC.

DR. R. VAREY (CERL) said that Dr. Viles had drawn attention to the difference, in terms of stonework damage, between dry deposition and wet deposition. She had also suggested that it was necessary to determine the relative contribution to stone damage of the acidity in rain and that from dry deposition.

Dr. Varey asked whether Dr. Viles would comment on the relative importance of acidity in rain itself, or the action of rain upon stone which had already received dry deposited pollutants. He wondered how important the rain was in actually promoting damage by the dry deposited pollutants.

DR. HEATHER VILES said that researchers in the BRE Study were well aware of the ways in which rainfall could be translated into decay and pollutants in the atmosphere could be translated into weathering rates.

Some of the work done had hinted that different decay processes could be ascribed to different pollutants in the atmosphere. However, they were not yet in a position to ascribe certain forms of damage, or certain amounts of damage, to either wet or dry deposition or any components of action within the wet deposition. It required a great deal more of both lab and field monitoring to answer that question properly.

MR. J. BEATSON (GLC, Scientific Services Branch) said that the weathering effect of pollution on buildings was a matter of great concern in London and other major cities. Many important buildings had undergone extensive cleaning in recent years during which centuries of grime had been removed by vigorous processes such as sand blasting. He wondered whether such cleaning methods might affect the rates of weathering and decay. There was concern in London that stone might be opened up to further attack by acid rain.

DR. VILES said that when stone was cleaned it often involved the creation of what was effectively a new surface as the crusts of grime were removed to expose a new stone layer underneath. That new surface could be relatively soft and would require some hardening up in the atmosphere, otherwise it would decay very rapidly. Studies of rock tablets, which themselves presented fresh clean surfaces, had thrown some light on the subject. These had been put through the same procedure as a building would be when it was cleaned, and the results had shown that the tablets would decay more within the first year after cleaning than they would later on. Contact with the atmosphere would create a new hardened layer after a period of about one year.

CLLR. J.J. ROONEY (Newtownabbey BC) asked for Mr. Burgess's opinion on a report issued 12

August 1985 by the _International Energy Agency's Coal Advisory Board_. Basically the report was optimistic that the overall EEC standard would be reached, for the following reasons:

1. the impact of the French nuclear programme;

2. the ever tightening German standards;

3. increased efficiency in energy use;

4. reduced use of heavy fuel oil throughout the EEC - in 1985 there was a glut of heavy fuel oils in the European market.

All those factors in combination with national environmental and energy policies were expected to bring about a substantial reduction in levels of emissions in the future.

MR. P. BURGESS, replying, said that UK emissions were declining; they were also coming down in other countries. In Germany (FRG) it was happening through the legislative route and in France it was occurring because of a large-scale change in fuel use. Within the EEC, the draft Directive on large combustion plant emissions could have a major impact in terms of further reducing emissions, although the measure was very far from being agreed. The point about heavy fuel oil was more applicable to other European countries than in the UK, but again there was a big changeover occurring, and high sulphur fuel oil would be used less and less in the future. To summarise, emissions would continue to decline and that was a factor which the Government had clearly in mind in its policymaking.

Invited by the Chairman to respond to Mr. Archer's points, MR. BURGESS said that he did not believe that the debate on acid rain could be compared to that on lead. The scientific evidence about the effects of acid rain was mixed. The evidence regarding freshwater fisheries in some areas was fairly clear cut, and (as he had made clear in his presentation) there was some evidence linking air pollution with forestry damage. However, it was by no means clear that a massive reduction in emissions would secure a positive benefit such as a raising of pH in Scandinavian lakes. The process of acidification had been occurring for many years and had taken 150 years to manifest itself. In some areas, damage had been observed after emissions had peaked. If emissions continued on their downward path for 30 years or so, environmental damage might slowly be reversed in the wake of that trend, although some localised damage might persist.

The Government was not requiring absolute proof before it decided on action; indeed, whether or not the point of proof would ever be reached was an open question. The scientific background was such as to justify a number of conclusions: both the conclusion the UK Government had reached, and those that other governments had come to. The balance of scientific evidence was not so weighted as to indicate that emissions had to be reduced massively over a very short period.

DR. VILES said that the BRE's research was concerned with sorting out the problems, regardless of what had caused them, although the whole debate about acid rain had focused the minds of researchers. However, the research had to be done whatever stage the debate had reached; for the future, strategies to overcome the damage caused by air pollution in its various forms would still need to be worked out and implemented, regardless of the outcome of the acid rain debate. She hoped that money would be made available for such long term work to be carried out.

DR. B. SMITH, referring to the question of the concentration of emissions at the Drax Power Stations, said that grouping power stations together did have one benefit in relation to effects in Scandinavia. The non-linearity aspect was enhanced by this concentration or grouping of power stations. Thus, the pollutant output in rain over Scandinavia was less than it would have been had the power stations been separated. An effective strategy to minimise the impact on Scandinavia of UK emissions was exactly that - to jam all the power stations together! Nevertheless, he endorsed the notion that Drax should be fitted with desulphurisation plant provided that it had the area capacity and bearing in mind the points Peter Burgess had made about secondary environmental disbenefits that might result.

The other point was that while the proportionality between emissions and depositions might be expected in Scandinavia, this did not hold true for "near in" effects. Picking up the analogy of a footprint used in his paper and presentation, Dr.Smith explained that receptor areas very close to the source would only average out what they received from the very first part of the footprint, since the source was too close to permit anything else. For sensitive UK areas such as Galloway in Scotland, reducing UK emissions would not produce a proportional decrease in acid depositions. Thus, action to reduce UK emissions would not necessarily benefit the home ecology to the same extent that it would benefit the ecology in Scandinavia.

CLLR. B.R. FITCH (Brighton BC) asked what effect the economic recession in the UK and Europe had had on emissions. With unemployment running at 15% in some industrial areas, there was an under-capacity in production and he wondered whether this had produced any effects on pollution levels in those areas.

MR. BURGESS said that as far as the analysts could tell, the decline in emissions since their peak in the early 1970s owed something to industrial restructuring. The UK and indeed other European countries had moved out of some heavy industrial manufacturing areas and the emission pattern had reflected that situation. There had also been changes in fuel use, with the coming on line of North Sea oil and gas. The view-foil he had presented had shown GDP growing rapidly in recent years, and emissions declining, which had indicated that something different was happening, ie new industries were coming on line which were not dependent on or large consumers of electricity. Whilst domestic and commercial consumption of electricity was expanding, it was being used far more efficiently. Demand for electricity might as a result actually fall in the future. All those factors helped to explain the decline in emissions, rather than recession per se.

DR. R.A. BARNES (Chairman) said that he believed Warren Spring Laboratory had done some work on the impact of the three day week during Edward Heath's government in the 1970s. He wondered whether Dr. Smith knew anything of this work, or whether he had in fact looked at the impact of the recent miners' strike.

DR. SMITH said that it was possible to detect short term responses, although it was complicated by the fact that meteorological conditions played such an extensive role in determining the concentrations or depositions at any receptor area. He had once tried to determine whether the effects of a weekend (when obviously there would be lower overall emissions) could be detected in terms of reduced deposition in Scandinavia. The short but honest answer was that they could not clearly be recognised although there was a suggestion of an impact. He had looked at the week surrounding Christmas, when industrial activity tended to be at a much lower level, and again believed that he could perceive some effect in terms of a change in the pattern of deposition in Scandinavia, but it was very far from clear-cut and could be due to other factors. He had looked in particular at the pattern of emissions and depositions when air masses had passed over the UK to Southern Norway. Since 1977 there did appear to be some trend, but he could not swear to it.

During the miners′ strike, the drop in domestic coal consumption would have been balanced by the burning of higher sulphur fuel, particularly heavy fuel oil, in power stations.

MR. S. CARDEN (Barnsley MBC) wished to question Peter Burgess on two points mentioned in his paper. First, he had said, "There is further scope for the substitution of gas for other fuel", and later he had said, "We are looking at ways of reducing the amount of fossil fuel used". He wondered whether Mr. Burgess would agree that the technology already existed for the clean use of the UK′s largest indigenous fuel source, coal. In view of the possible devastating effects on coal field communities of policies which switched away from coal use, he asked for further details.

MR. BURGESS said that while there was some scope for further switchover to gas, he did not believe that it would replace coal to any great extent in the future. However, nuclear power might certainly displace coal to some extent. The Government's policy was known. The Sizewell enquiry had been held. Some new nuclear power stations were due to come on line shortly. Further into the future, more nuclear capacity was envisaged. Inevitably, that would reduce the use of coal and reduce UK emissions.

DR. R. BARNES (Chairman) asked Dr. Smith about the chemistry involved in his model. He wondered whether figure 4 of his printed paper would have been affected by a limit on the amount of ozone available to convert SO2 to SO4.

DR. SMITH said that the model had allowed for conversion of SO2 to sulphate at a constant rate. He agreed that the situation might have been over-simplified, since the conversion rate was dependent upon the presence of other oxidising material such as ozone. In turn, that could depend significantly upon the breadth of the plume and the amount of ozone in the surrounding air. Nevertheless, the model did contain some air chemistry, however simplified, and this was manifested in the way the deposition velocity was allowed to be a function of time, since sulphate,the oxidised product, dry deposited more slowly than the primary pollutant, sulphur dioxide.

Dr. Smith did not believe that a more elaborate air chemistry input to the model would have significantly altered the results. The model appeared to be extraordinarily robust to such inputs: the parameters could be changed, the oxidation rate could be doubled, the non-linearity could be trebled and still the conclusions emerged almost unchanged.

The physical concept that he had described, ie the footprint and averaging over it, was so basic to the whole process that no matter how the model was tuned, the answer would still be the same.

DR. S. SIMMONS (Midland Environment Limited) suggested to Dr. Smith that his model, with the footprint hypothesis, was based on long-term average deposition rates. The main problem associated with clusters of prominent sources such as those in the Drax area, was that they might lead to significantly increased short-term variability and significantly elevated short-period peak deposition rates. If the damage mechanisms were such that the damage was mainly caused by short periods of high deposition rather than an increase in long-term averages, then it would be more appropriate to look at the "worst-case" short-term impacts associated with clustering of sources, rather than longer-term averages.

DR. SMITH agreed that this might be expected. However, his study at one of the EMEP stations in Southern Norway had shown it not to be the case. When air masses were crossing over the main source areas of the UK and impacting on that particular station, he had found it incredibly difficult to distinguish their presence. Obviously, both concentrations and depositions varied from day to day but while it might have been expected that when the plume from Drax and Eggborough travelled across the North Sea and hit that monitoring station in Southern Norway, it would have significantly increased the measured concentrations for that day but in fact that had not been the case. He believed the explanation to be that the plume remained over the monitoring station, when it was indeed there, for such a relatively short time (eg 1 or 2 hours) that its impact in terms of the total deposition over a 24 hour period was lost. Thus, he did not think that grouping together of power stations would produce occasional incidents of very high depositions at remote receptors.

MR. G. STOTT (Scottish Development Department) expressed concern that the audience might regard the problem of acid deposition as one affecting only countries overseas, and not the UK.

Not being a meteorologist himself, Mr. Stott sought Dr. Smith's comments on a few points. First, most areas of the UK did not have prevailing winds, only predominant winds. Secondly, pollutants did not simply disperse in one direction; frequently, they returned in a particular air mass to affect various parts of the UK itself. Indeed, research work was now underway in the UK to measure the effects of acid deposition in the Galloway Region and in Cumbria.

Mr. Stott had heard of Canadian research which had shown that removal of a fairly local source of sulphur dioxide and other pollutants would, within a relatively brief period of 3 years or so, effect an improvement in ecosystems. Streams and lakes which had been totally acidified would regain their fish life and balance of plant life and return to normal.

Mr. Stott asked for the speakers' views on the near effects of sulphur and nitrogen oxides emissions, both from the UK itself and from Europe.

DR. SMITH reminded the audience that Peter Burgess had summarised the position by saying that 30% of the UK's own emissions were deposited within the UK. That probably represented a few grams per square metre per year of deposited sulphur. Dr. Smith agreed that there was no prevailing wind blowing all the UK's pollution towards Scandinavia. If that were indeed the case, the Scandinavians would have experienced a still more serious problem. He also agreed that it was true that the lakes and forests in the UK were at risk from the UK's own emissions.

The Canadian research to which Mr. Stott had referred had, he believed, related to the Sudbury, Ontario, aluminimum smelter, from which was emitted the equivalent of 1/12th of the entire UK SO2 emission - just from one small group of stacks. The situation around Sudbury had been improved enormously by controls at the plant. However, there was no one source of that magnitude within the UK. Nevertheless, in the Pennines, downwind of the industrial area of Lancashire, trees had in the past been difficult to grow. Now, because of a drop in emissions, trees could be grown in parts of the Pennines where they would have died before.

The acidic depositions in Scotland had shown some response to the general drop in UK emissions in the past few years; this response was probably not a linear one, but at least there was some improvement. Galloway, in South West Scotland, received a good deal of acidity from UK emissions but also from air masses coming in from over the Atlantic. This background element, or "undecided component" in Peter Burgess's words, had not yet been mentioned. Air coming in from the Atlantic did contain a small amount of sulphur. The origin of that sulphur was not completely clear. Some might have originated in Europe, been swept out over the Atlantic and then turned back inland again. Natural sources, eg plankton in the sea, gave off dimethyl sulphide, which was oxidised to sulphuric acid. On the other hand, it was quite conceivable that some 5-10% of sulphur coming in to Europe had originated all the way across the Atlantic in the United States. Thus, the problem was almost global in scale.

DR.VILES said that while it was difficult to establish whether the pollutants which affect buildings had originated at long range or more locally, the BRE team had come up with some interesting anomalies within the general picture which they had obtained. As far as they could tell, these anomalies could only be due to very localised sources of atmospheric pollution which did not disperse but impacted on the surrounding buildings. These local sources had been very important in the 19th century when many low house chimneys emitted smoke and other pollutants from coal fires, with an obvious impact on surrounding buildings.

The effect of local emissions was demonstrated by a study which involved exposing stone tablets in the Bedfordshire brickfields area. The high rate of weight loss was due to very localised emissions from the brickworks chimneys. However, this was not usually the case in Britain and most building damage seemed to be due to a more generalised distribution of pollutants.

MR. BURGESS, returning to the original point, said that it was difficult to distinguish the impact of air pollution from other effects and stresses. The acidification of the Galloway lakes could be traced back to the Industrial Revolution. In the case of other forms of damage, the evidence was less clear cut and it was difficult to disentangle the effects of pollution from other effects.

CLLR. J.C. BLEWITT (South Oxfordshire DC) expressed admiration for the first two presentations and sympathy with the third speaker, Peter Burgess, whose unhappy task it had been to outline the Government's thinking on acid rain. Cllr. Blewitt considered this a difficult job for any speaker, given that the Government's policy seemed to be to do nothing because of the costs involved. He was concerned that the improvements brought about by the 1956 Clean Air Act might be halted or reversed by Government inaction, and pressed Mr. Burgess for further details of actual policy, since he regarded the lack of positive measures as an attempt to hoodwink the Scandinavians, the EEC and indeed the UK population.

MR. BURGESS said that there was no question of the Government reversing other air pollution control policies. A considerable sum was spent on air pollution control, particularly that required by HM IAPI. His presentation had referred solely to the problem of acid rain. He did not consider that the Government line on control of sulphur emissions could be regarded as a reversal of all that had been achieved in the past. Indeed,the policies of the past were being pursued. There was a continuing drive for smoke control, for example. There was also continuing control on industrial emissions.

The Government policy on acid rain had been stated in a White Paper, published in 1984 in response to the House of Commons Select Committee on the Environment, as follows:

> "The Government is determined to continue the attack on air pollution. The UK has already made a substantial contribution. Our emissions of SO2 have fallen nearly

> 40% since 1970. The Government will build on this firm foundation and intends to achieve further reductions in national SO2 emissions, aiming at a reduction of 30% in 1980 levels by the end of the 1990s ... and then to aim for the same reductions in NOx emissions."

That made the Government position perfectly plain. Emissions were expected to fall by the turn of the century, for a variety of reasons. What the Government was not prepared to do was to install flue gas desulphurisation on power stations or other major combustion plants to reduce emissions. However, that could not be considered a reversal of the UK's air pollution control policy. In common with many other countries, the UK had for many years dispersed gaseous combustion products. The argument in Europe now centred on the question of whether this could still be considered an effective or acceptable policy. The alternative was to wash the gases. The UK Government line was that this should not be done. On balance, the Federal German government had come to a different conclusion. Other countries were at various points in between those two extremes.

DR. R. BARNES (Chairman) wished to put a question to Peter Burgess. He said that various speakers had alluded during the discussion to the different sources that affected different targets. For example, it had emerged that buildings were particularly affected by low level, local emissions, of which traffic was a major source. The international pressure on the UK to control emissions stemmed from the impact that UK emissions had on other countries, which obviously varied according to the location of the countries concerned. Dr. Barnes wondered whether DOE had progressed with a small task that had begun years earlier, looking at the costs and benefits of control of different categories of emitter.

The "aim of policy" which Peter Burgess had described did not really segregate the indigenous targets - sensitive parts of Galloway, and historic buildings - from the more distant targets.

MR. BURGESS said that DOE had attempted cost/benefit studies with reference to SOx and NOx control. The essential problem was that while costs of control could be described, no true figure could be derived for the environmental benefits which would result. As to disaggregating the study and looking at local benefits, that had not been done. The difficulty was that it was difficult or impossible to disentangle the impact of long range and more local sources. In the UK itself, severe local effects were no longer apparent although such local effects could be seen in the Eastern Bloc countries. DOE had concentrated on looking at the costs and benefits in the European context, which was the correct framework in which to examine the problem. However, he did not feel that DOE had been very successful in their efforts so far. Neither did other similar studies inspire him with confidence.

MR. R.J. PERRIMAN (HM IAPI) said he wanted to correct an impression which some members of the audience seemed to have gathered from Peter Burgess's talk, that the Government policy was to do absolutely nothing about the emissions associated with acid rain. Mr. Perriman made it clear that if and when the CEGB produced proposals for new fossil fuelled power stations, as Chief Industrial Air Pollution Inspector he would argue that the best practicable means would be to abate SO2 and NOx emissions by whatever technology was then available. Indeed, the technology was available now. The difficult question for the Government was whether or not the grounds existed for retrofitting existing power stations. The Government's assessment of future trends in UK emissions was based on the assumption of some increase in nuclear power generation, but also on the assumption that any new fossil fuelled power stations would be equipped with the best available treatment for flue gas emission control. The crux of the matter was whether to spend £1.6 billion on a crash retrofit programme to secure an earlier and faster rate of reduction in emissions than would otherwise occur.

CLLR. E.E. PITT (Walsall MBC) said that in her view Margaret Thatcher and the Government had done a great deal to control air pollution in the Walsall area - they had closed the factories. On the international front, however, a group in Oslo was so outraged by Britain's indifference to the damage that UK emissions were wreaking in Norway that they had asked their Government not to send the traditional Christmas tree, as a protest.

Mrs. Pitt wished to move a resolution for consideration of the Conference, as follows:

> "That this conference urges the Government, in the interests of international co-operation, to make available more funds for research into acidic emissions, to ensure that clear data is made available under the Convention on Long Range Transboundary Air Pollution, and to take an active part both under that Convention and the Helsinki Conference Agreement to obtain the necessary

> information; and further calls on the Government to report to Parliament annually the steps it has taken under the Convention and other Agreements."

The resolution was remitted to the Conference Committee for clearance before being posted up for examination by delegates prior to a vote being taken at a later session, when it was passed unanimously.

Speakers: Mr. R.C. Payne and Dr. A.K. Coleman

MISS J. DUNMORE (NSCA), opening the discussion, referred first to a remark made by Peter Burgess earlier in the day. He had said that most of Britain's air pollution problems had been brought under control, with the major exception of gaseous emissions from large combustion plants. However, the two papers presented during the afternoon had indicated a clear concern about a wide range of other air pollution problems in the UK, and showed that considerable effort was being expended on finding a solution to those problems.

Mr. Payne had presented the excellent results of a great deal of research effort on small automatic coal fired boilers. The NCB would never have gone to such trouble and expense if there was not still a concern to bring smoke problems under control in the areas where they persisted, and to enable a valuable indigenous fuel to be used cleanly and efficiently. The NCB's research team had achieved their objective with this latest generation of boilers, which had the additional advantage, apparently, of being operator-proof, which earlier generations of "smoke-eating" appliances had not proved to be.

The National Society for Clean Air, which had contacts with many similar organisations abroad, was aware that smoke continued to be a problem in many other parts of the globe. Christchurch, New Zealand, for example, would benefit from the technology developed by the NCB and British manufacturing firms. Miss Dunmore asked whether there was any intention of marketing the small automatic coal fired boilers in other countries, or of bringing the development to the attention of governments and non-governmental organisations overseas. In the acid rain debate, Britain had sometimes been accused by her critics on the Continent of having solved its own air pollution problems via application of the Clean Air Acts, only to cause problems elsewhere by the high level discharge of gaseous pollution. But she considered that the two problems were separate, and that Britain had much to teach other parts of the world about basic smoke control technology.

Turning to the paper by Dr. Coleman, she said that he had highlighted the need for industry to be acutely alive to the public perception of industry's operations and public sensitivity to any resulting environmental impact. Dr. Coleman had been disarmingly frank about his company's operations and the public reaction to them. Miss Dunmore had recently had the task of coordinating the NSCA's response to the DOE on access to environmental information, so had found the emphasis on this point in Dr. Coleman's address particularly interesting. She said that industry was perhaps best served not only by showing the public that they had nothing to hide, but by developing a sense of timing. While Re-Chem had gone to considerable trouble since 1984 to acquire data and then try to arrange for its release in the most effective manner, the public concern to which Dr. Coleman had referred and the media interest in Re-Chem's operations had begun well before 1984.

She believed that industry should consider the public reaction to its operations from the planning stage onwards, and on a daily basis. She was fully aware of the technological and financial demands faced by industry, particularly the need to make a profit, but she felt that industry should be prepared to anticipate public reaction to any aspect of its operations. That way, industry would not be at a loss when media and public interest blew up in their faces, and indeed might be able to prevent such a furore. She asked Dr. Coleman for his comments and in particular whether he considered that Re-Chem might have done better to establish a system whereby the public could readily gain access to information about the plants' operations and their impact on the environment, from the very beginning.

MR.W.F.SNOW (Warrington BC) referred first to the earlier generation of smoke-eating appliances, and the operating problems that had been experienced with some of them, which required particulate matter to be cleared from quite complicated flueways. The regular clearing of the flueways had been beyond the capabilities of the average householder, and certainly beyond the capacities of the elderly. He wondered to what extent such problems had been overcome in the new generation of appliances. Referring to the "Coalflow" service scheme, whereby for an annual fee the householder could have a complete service for their boiler, Mr. Snow wondered what order of fee would be charged for servicing the domestic-scale appliance. His final question to Mr. Payne concerned the measurement of the standard which the appliances were required to meet. As he recalled it, the standard was expressed in grams of permitted smoke emission per hour according to the rated capacity of the appliance, and that measurement had been made using an electrostatic precipitator. He asked how local authorities could determine that the appliances were actually working within the prescribed limits, once installed.

Turning to Dr. Coleman's paper and problems of liaison with the public, Mr. Snow asked for Dr. Coleman's comments on the arrangements made by Re-Chem to ensure adequate liaison between the company, the local authority, IAPI and the members of the public affected by its plants. Mr. Snow believed such liaison to be the best way to proceed. Enforcement, which sometimes led to court action, was really a last resort. What was essential was to ensure that proper liaison was effected from the outset.

MR.R.C. PAYNE, responding to the first point about flue cleaning, said that in the initial generation of coal-fired batch fed room heater appliances, the cleaning out of particulate matter had been rather more complex than it should have been, because of the design of the appliance. Later developments of the batch fed unit had to some extent overcome the problem and made the cleaning job much easier. He was aware that some users, particularly the elderly, had found the instructions about flue cleaning difficult to understand. Sometimes the operation had been very difficult to carry out for someone on their knees, with the mechanical advantages all in the wrong direction. But, learning from experience, the NCB had concentrated on that aspect in the new generation of appliances. They had attempted to ensure that the domestic units could be self-cleaning and all designs had vertical flueways. Wherever possible, NCB had opted for rectangular slot boilers; they had also investigated various mechanical devices, starting with a chain but progressing to rods which could sweep through the flueways and keep them clean. These rods were activated by an external lever that was quite easy to use. The idea was that the operation should be carried out usually when the boiler was refuelled, by reciprocating the lever two or three times, which ensured that the boiler flueways stayed clean and that the boiler remained efficient.

Turning to the second question on the "Coalflow" scheme which had just been introduced, Mr. Payne said that the standard charge had not actually been fixed. However, he thought that for the small boilers (60,000 Btu and upwards), the standard charge would be in the order of £60 - £80 per annum.

On the question of how to ensure that the appliances performed as well in the field as they had done in the laboratory, Mr. Payne explained that they had conducted both gravimetric tests, using an electrostatic precipitator, and optical monitoring. In some cases, the optical monitoring method could be applied to a field unit. The CRE had done this and found that the results, by and large, conformed to the laboratory experience. The other obvious indicator was the visual smoke emission from the stack. However, there had been very little evidence of visual smoke emission from the stack of any of the forty or so new design units that had been operating in the field, some of them for up to three years. The gravimetric smoke measurement tests showed that even at high turn-down, smoke emission levels were well below the five grams per hour standard: it was, on average, 2-3 g/h. Thus, the new automatic coal-fired boiler conformed to the standard over the full range of domestic use.

DR. A.K. COLEMAN said that a number of liaison committees with which his company had been involved had failed in their purpose. The essential ingredient was a willingness on all sides to recognise and appreciate both sides of the argument - and there were always two sides to any argument. Also, the change in attitudes towards release of information had been a very recent phenomenon. Access to information was by no means universally supported by industry; indeed, many firms were reluctant to release data. A number of industries viewed Re-Chem's activities with concern. To some extent, Re-Chem was perhaps more favourably inclined towards freedom of information because of their awareness of public concern and their sense of being misrepresented by the media. However, their perceptions and their response would not perhaps correspond to that of many industrial organisations.

The make-up and chairing of the liaison committee was also critical. Clearly, it should have a proper mix of representatives and a strong person in the chair to direct the discussion to the real issues of concern and not the more peripheral ones which quite frequently arose in any debate on sensitive operations. The liaison committee set up at Fawley was considered by both sides to be working well. Those in Bonnybridge, Scotland, and Pontypool, South Wales had been set up following much perturbation amongst the public, and considerable media interest. Whether or not matters would have been better dealt with if such liaison committees had been established there long before was difficult to tell, but with hindsight (and hindsight was always a valuable teacher) probably matters would have been eased.

MR. T. JONES (Torfaen BC), picking up on Dr. Coleman's comment that hindsight was a wonderful teacher, asked what, with hindsight, Dr. Coleman thought of the siting of the Re-Chem Plant at Pontypool, bearing in mind the proximity of the local community, the south westerly winds which bore the plume from the

Re-Chem stack to the local community, and ten years of complaints from that community. The plant was sited in a valley, with a high mountain to the west and sloping ground to the east. The prevailing south westerly winds swept in across the valley picking up and carrying the plume to the highly desirable residential area from which complaints emanated vociferously over the years.

Referring to the last page of Dr. Coleman's paper, which had stated,

> "...it is unfortunate that ill-informed comment and mischievous misrepresentation of the facts has so often been the means to exploit both communities and plant operators for political gain, personal glorification and media sensationalism...",

Mr. Jones said that Dr. Coleman had also referred to the sensitivity of the local population. He agreed that the population were sensitive but not that they had been sensitised simply by the exploitation of their concern. They were sensitive to a continuing problem - one of straightforward nuisance, setting aside the discussion of PCBs and dioxin - and they were sensitive to the fact that nothing appeared to have been changed at the plant in response to their complaints.

Turning to the question of government funding, raised by Dr. Coleman in his paper, Mr. Jones said that he understood that some European governments actually provided funding to aid private companies in the disposal of hazardous waste. Mr. Jones considered that it was high time that the UK government woke up to the fact that disposal of hazardous waste was a national problem. Current level of demand for incinerated disposal was 56,000 tonnes, while the merchant incinerator capacity was just 61,000 tonnes. He thought a national policy on hazardous waste disposal would soon emerge if just one more merchant incinerator plant were to close. He considered such a policy essential and that it should cover such matters as transportation of waste and siting of plants. The sooner the government recognised the need, the better; such disposal should not simply be left to the private sector.

Finally, Mr. Jones referred to the statement in Dr. Coleman's paper, that 70-90% of the particulate matter in stack emissions consisted of neutral salts. He wondered what the other 10-30% consisted of.

DR. COLEMAN said that he and Terry Jones had debated on many occasions the question of the siting of the Pontypool plant. With hindsight, it would have been preferable to have sited the plant in Avonmouth or somewhere similar. However, he was sure that the local community in Avonmouth would prefer that the plant was in Pontypool! The American syndrome, " Not in my backyard", applied equally well in the UK. The aim had to be to operate the plant so that people in the area surrounding the plant could, on the whole, accept its presence. That had been the objective of the Re-Chem Company since the Pontypool plant had begun operating in 1974.

He felt that Mr. Jones's comment that nothing had been done to improve the plant since 1974 was rather unfair. The plant management consistently recorded the complaints made by local residents, and had charted a decline in the number of complaints, which showed that the company was making progress in overcoming problems. Dr. Coleman said that if complaints were related to political events then a very clear correlation could be seen, time and time again, in the peaks and troughs. May 1985 (the time of local government elections) had been no exception, but things had been pretty quiet since then. He made it clear that he was by no means saying that all complaints were politically motivated; he was not complacent and understood and appreciated the fundamental basis of many complaints.

As far as government funding was concerned, Dr. Coleman declared that he would welcome such input. However, the present Government was firmly committed to the principle of "polluter pays", and, in the case of hazardous waste, interpreted this as meaning not that the government or individual members of the community should pay to dispose of the waste which necessarily arose from many activities and manufacturing processes, but that it was for the industry which produced such wastes to pay. The problem was that incinerator operators had been unable to persuade the generators of waste to pay the real cost of disposing of their waste without pollution. Eventually, the private companies engaged in hazardous waste incineration might, not surprisingly, give up because they were simply not getting an adequate return on their investment. The task of hazardous waste disposal might then be handed over to the public sector - which would be faced with exactly the same problem. The public sector would probably meet the situation by seizing on the Government's commitment to the polluter pays principle, saying that it was not for them to bear all the costs, but that the waste producer should pay.

Referring to the particulate emissions, 70-90% of which he had said in his paper was neutral salts, Dr. Coleman said that he had shown a number of the components of the remaining 10-30%. Additionally, silica was a common constituent in incinerator ash - it had not been measured because it was not considered particularly interesting. The company expended its efforts on identifying those substances which the regulatory authorities required to be controlled.

MR. R.A.B. HALL (Greater London Council) said that the GLC operated a solid waste incinerator, so he had some sympathy with other incinerator operators, particularly those dealing with hazardous waste. When such incinerators were operated well, they could be considered to be full of advantage in comparison with the other options such as landfill, flytipping etc, which had caused great problems in the past. However, he had a question about the standards applied at the Pontypool Plant.

Dr. Coleman had said that the level of particulate emission aimed for was 460 mg per cubic metre (see fig. 1 in the paper). In his presentation, he had mentioned that the new limit was 115 mg/m3, and he was probably aware that the proposed new EEC limit was 50 mg/m3. Mr. Hall considered that this fall in the limits indicated a public awareness of the problems and a public interest in achieving ever lower levels of particulate emission. While the 50 mg/m3 limit had not yet been adopted in the UK, he expressed surprise that Re-Chem had not considered lowering their target emission level from 460 mg/m3, in order to meet the expectations of the public in the area .

Referring to dioxin, Mr. Hall asked whether measurements of dioxin levels had been made at any of the Re-Chem plants, and whether Dr. Coleman considered the plants effective at destroying dioxin. The paper had twice mentioned that the plant aimed to achieve an operating temperature of 1000 oC, with a residence time of at least two seconds. Mr. Hall wondered whether this was significant - or whether 900 oC for three seconds would be equally efficient, or 800 oC for four seconds. He asked whether any other authority had visited the plants, carried out surveys and produced results relating to dioxin emissions.

DR. COLEMAN said that the Pontypool Plant had been required to achieve particulate emission levels of 460 mg/m3 in 1974, and that standard still applied. The 115 mg/m3 level was the standard applied to new plants now. However, Re-Chem had been looking at ways of reducing particulate emission and had carried out pilot-scale trials using an irrigated electrostatic precipitator, which had achieved an impressive reduction in particulate levels, down to 20 mg/m3. Naturally, extrapolation from the pilot scale to the full plant situation had to be done with care. Nevertheless, the trials suggested that the technology was available. The factor lacking was the confidence to invest the necessary capital in the plant. The company had to make the decision and was faced with the choice between the investment in new control technology, or closing the plant. However, Dr. Coleman was not yet in a position to indicate which way the decision would go, although he believed that a firm decision would be taken in the very near future.

Turning to discussion of dioxins, Dr. Coleman said that the plant's capacity to incinerate PCBs while keeping dioxin emissions under control was thoroughly understood. The plants had been independently monitored by the Harwell Laboratory, who had looked specifically for dibenzodioxins and dibenzofurans, and quite impressive results had been obtained. Part of the monitoring regime established by the company itself involved the sending of samples for independent analysis, looking specifically for dibenzodioxins and dibenzofurans. Such analysis had already been carried out by Harwell and by Professor Rappe in Sweden, the leading authority on dioxin analysis. Those results continued to encourage Re-Chem that their plants were capable of doing the job properly. As far as temperature versus residence time were concerned, the argument about what was ideal could b carried on indefinitely. Back in the early 1970s it was considered that the temperature necessary for destruction was 850 oC with two secs residence time. The DOE Waste Management Paper No.6 suggested 1100 oC for two secs. That figure had been derived from US standards. In 1979 that US standard had been uprated somewhat, rather arbitrarily,to 1200 oC, plus or minus 100 oC. The revision was probably intended to overcome a weakness in the original standard, which had simply quoted an absolute figure.

However, the standard was in itself indefinite. The specific site of the temperature within the furnace was not clearly designated, and the only way that it could be gauged was by means of a temperature recorder somewhere on the side of the incinerator. Dr. Coleman said that he remained unmoved by those who said that the incinerator should operate at 100 oC higher than it currently did: he had the proof that the incinerator destroyed PCBs and dioxins at its normal operating temperature. There was a great deal of safety built into the system. He could accommodate an operating temperature slightly below 900 oC in cell 1, since he knew he had many more seconds of residence time in subsequent cells. He hoped that public disquiet would be allayed by the results; by the facts presented to them. The Company had actually gone beyond sampling its own emissions, and was sampling for PCBs and dioxins in plants and animals in the surrounding environment. He hoped that all the research data released would, in the course of time, act collectively to dissipate public concern.

DR. B. SMITH (Meteorological Office) wished to comment on a particular point in Dr. Coleman's presentation: that, when depositions had been sampled around the plant, there had been very little correlation between the magnitude of the depositions and the wind direction. However, Dr. Smith considered that although wind direction was a very important parameter it was not the only factor to be considered in such sampling. He believed that, although it might be difficult to do, some attempt should be made to correlate wind direction and atmospheric stability. To illustrate the importance of this exercise, he said that in a south westerly wind, it might be expected that there would be good mixing in the vertical. This would mean that material leaving the stack would reach the ground quickly, close to the incinerator. There would be fairly high concentrations at the ground, and hence fairly large depositions. However, downstream mixing in the vertical would reduce those concentrations very rapidly. On the other hand, in more stable conditions, perhaps towards evening, mixing would be gradual and a maximum concentration would not be reached until several km downstream; thereafter, concentrations would remain relatively high because of the very gradual mixing and the deposition would persist for much longer distances. In very stable conditions, the plume would travel almost horizontally and might not impact for perhaps 10 km or more, until it met a hillside. Thus, he did believe that the question of atmospheric stability and its relationship with wind direction should also be included.

DR. COLEMAN, responding, said that of course Dr. Smith was right to comment on the importance of atmospheric stability. In turn, he considered that by releasing the data not only to the local community, but also to the scientific community (some data had recently been published in the journal Chemosphere), the company were inviting such observations on their research programme and results, all of which would be very interesting.

The second point was that, whether or not the Company had correlated the results properly, there were no unexpected highspots to be explained away.

MR. G.R. CHARNLEY (Southampton CC) asked Mr. Payne whether he had any noise emission data relating to the small coal fired automatic boilers, particularly the domestic scale boilers.

Turning to Dr. Coleman's presentation, Mr. Charnley said that Re-Chem had carried out some excellent liaison work with the local community around their Fawley Plant. He wondered whether they had considered what the local reaction might be if a decision were taken to incinerate PCBs at the plant.

MR. PAYNE said that the twin tub unit had two motors, one to drive the core screw and one to drive an impeller that provided the forced draught combustion air. These were fairly modest motors. For the 60,000 Btu unit, a 40 W motor was required for the fan.

The rating of the motor driving the feed screw was similar.There was no intrusive noise. Some sound level measurements carried out in a kitchen where one of the units had been installed showed the noise level to be no higher than that emanating from a freezer in the kitchen. That was considered to be acceptable. Perhaps a slightly greater source of noise came from the crunching of the coal particles in the feed screw. Initially, the design had been for an Archimaedean screw; this had been changed, for cost reasons, to a centre-less screw spiral which was much quieter: although it ran a little faster to get the same coal feed rate, it was definitely quieter. The possibility of using a smaller size coal than singles was also being examined. Tests had shown that coal sized 1/4 to 1/2 inch, rather than 1/2 to 1 inch, was extremely quiet in terms of the noise levels made as the coal was screwed along to the retort.

DR. COLEMAN said that it was inconceivable that the notion of burning PCBs at Re-Chem's Fawley Plant would gain acceptance amongst the local community. There was too strong a groundswell of public opinion against such a notion. This opinion was not technically or scientifically based - there was no operating reason why PCBs could not be incinerated at the Fawley Plant. There was indeed a background level of PCB in the environment against which the plant's operations could be judged. But it was not at the end of the day a scientific issue, but a political one. People did not want the "risk" - it was a fundamental reaction against something which might go wrong. The Re-Chem Company could put forward all the arguments they liked about the capability of the plant to do the job properly, but the local community would resist the development.

However, those who opposed the incineration of PCBs did not trouble to consider the options. The reason that PCBs were found in the environment and in trace amounts in the human body was because, prior to 1974, there had been no alternative to the
landfill disposal of PCBs. But people did not consider the overall balance of environmental benefit. The main concern was to protect the local environment and have such plant anywhere but on their own patch. In conclusion, Dr. Coleman said that they would have a considerable fight on their hands and the one way to destroy the good relationship built up with the local community around the Fawley Plant would be to announce that they were going to burn PCBs. There was no intention of burning PCBs at Fawley in the foreseeable future.

THE CHAIRMAN invited the speakers to wind up the discussion, and respond to the remarks of the discussion opener.

MR. PAYNE said that as far as interesting other countries in the coal burning appliance developments was concerned, CRE received a large number of visitors from many different countries. They were given the opportunity to look at developments across the whole range of CRE's activities, on both the industrial and domestic sides and great interest had been shown in the automatic boilers. CRE also had an overseas licensee in Austria for the self de-ashing stoker development. From them, CRE had learnt that a smaller size of fuel than singles could be used satisfactorily and as he had mentioned earlier in the discussion, the use of such fuel was being seriously considered since it had many advantages. It lent itself readily to low cost pneumatic handling. Quite a small fan could be used to blow coal particles of this size through a pipe one and a half inches in diameter. The same fan system could be used for both the coal feed and the ash removal. CRE were seeking to develop a comprehensive system which used just one power source for both the coal handling into a hopper, and the ash removal, ie taking the ash and putting it into a skip or plastic container of some sort. That licensee had since sub-licensed into Germany.

A good deal of interest, particularly in the domestic and commercial appliances, was coming from the United States. That type of appliance industry did not exist over there and it was considered that there was enormous potential for a hands off, user friendly coal burning appliance of the small automatic type. CRE was pursuing enquiries with various American interests. The other area where interest had been shown, but a specific response was still awaited, was China, where there was enormous potential for that sort of technology. Whether or not the consumers there could afford it remained to be seen but certainly a strong degree of interest had been shown in the appliances.

To summarise the discussion on his presentation, Mr. Payne said that what CRE were trying to develop was something that satisfied UK legislation; that was trouble-free so that the user did not have to get involved and presented no more of a difficulty than any other piped fuel; and something that was backed by a scheme which would guarantee the coal quality and iron out any conceivable problems that might possibly emerge with the hardware. Although no problems were anticipated, following the launch it was essential to have some proper scheme to sort any problems out. Here, the 24 hour emergency scheme would come into play. CRE would be monitoring the service reports received very carefully and at the end of all this they hoped to provide a unit that was as reliable as a fridge, freezer or twin tub washing machine.

DR. COLEMAN, responding to Miss Dunmore's comments, said that it had to be borne in mind that Re-Chem was, and always had been, a very small company. It had very limited resources to spend on funding and taking part in liaison committees. The job of meeting local community groups had always fallen to the managing director or the technical director, who would leave what they were doing and dash down the road to a meeting. Larger companies had whole divisions that did nothing else but take care of community relations and PR.

Also, ten years previously, the general attitude amongst industry had been to maintain a low profile and keep their heads out of the firing line. Re-Chem had been no different although they were maturing with age and experience. They had begun to realise some of the benefits in going out to the community and releasing information. But it was only comparatively recently that Re-Chem had accepted this as a way forward. Even within the company itself, that acceptance was not universal. He was the first to admit that the standard of Re-Chem's operations was at its current level partly because of the activities of local pressure groups. At the same time, these groups were often a considerable nuisance to the company and made life very difficult. But being objective, he was glad of that since in his own case he was much more knowledgeable about his company's operations than he might otherwise have been.

While industry in general did not yet universally accept freedom of information, speaking as a scientist rather than a Company Director, he thought that release of data to the public was to be encouraged, and that a lot of good could stem from the scientific debate which followed release of data to the scientific community. As yet, it was early days. Industry's reaction to freedom of information would depend to a large extent on how the public handled the information that they were given, and what use politicians made of it. He did not apologise for his earlier remarks about the mischievous misrepresentation of facts. He thought that the politicians had behaved in some cases disgracefully in their dealings with Re-Chem. He did not believe that such politicians really had at heart the interests of the community which they purported to serve.

Speakers: Dr. F.J. Langdon, M.J.T. Smith and M.J. Gittins

MR.H.DAWSON (Chairman, NSCA Noise Committee, and Rolls Royce Limited) referred first to the very interesting paper by Dr. John Langdon, which had covered the subject of noise and health impairment. Noting that Dr. Langdon had covered the range of effects associated with noise, including stress, Mr. Dawson said that he had perhaps omitted the stress associated with the low frequency end of the spectrum, focusing instead on the problems associated with din-type noise.

The work of the Noise Committee, and data fed to the Committee, had shown the great importance of doing something about low frequency noise. Standards related to it were scanty, buildings and other structures were virtually transparent to it and most data on human effects were quite anecdotal. The NSCA would welcome more research in this area and Mr. Dawson sought Dr. Langdon's comments.

Turning to the effects of aircraft noise, Mr. Dawson picked up on the comment about the use of tranquillisers amongst residents around airports. He asked Dr. Langdon whether he thought this use of tranquillisers would change as a result of the developments to which Mike Smith had referred in his paper.

On the other hand, he wondered whether it was simply a reaction to the general quality of life. As the Wilson report had shown, some people became acutely sensitised to the whole environment in which they lived.

On the question of traffic noise, Dr. Langdon had stressed that disturbance to sleep was probably not a major impact on health. However, Mr. Dawson reminded delegates that an OECD study had shown that someone driving a 250 cc motorbike across Paris at dead of night could wake half a million Parisians.

Turning to the paper by Mike Smith, Mr. Dawson said he had found this fascinating, particularly the early references to the "angry communities" whose attitudes were reflected in an entirely responsible and influential manner by the National Society for Clean Air, which was exerting legal and political pressure for change and improvement through various agencies. Noting that the noisier aircraft were being phased out, he anticipated with interest the beneficial effect on the mental health of the community. Looking at the longer-term development in aircraft design, he wondered whether the trend would be for bigger - even 1000 - seater aircraft, which would result in fewer total air traffic movements. Also, as the noise output from aircraft seemed to be inversely proportional to their size, with whispering giants and ear-piercingly noisy dinky craft, such developments might suggest a quieter future.

Moving on to consider Mike Gittins' paper on entertainment noise, Mr.Dawson spoke with some feeling on the subject since he had attended a disco the previous evening, and had suffered from the high noise output, feeling cloth-eared as a result. While there was some debate about whether disco noise in itself represented a hearing hazard, he was convinced that the cumulative effect of disco noise on top of a noisy work environment could have a serious adverse effect, bearing in mind individual sensitivities. He considered the paper to be good news for audiometricians; audiometry had been practised to a far greater degree in industry in recent years, but it could not reveal whether people's hearing had been damaged at work or at play. That might lead to some very interesting legal decisions. Speaking of legal aspects, Mr. Dawson considered that it might not be long before an employer was prosecuted because a barman had been deafened in a disco.

Mr. Dawson believed that the three excellent papers on entertainment noise had reinforced the view that there was a great role for the NSCA to play as an ethical pressure group taking the lead on the control of noise in its widest community sense.

DR. J. LANGDON, replying to various points raised by Mr. Dawson, said that hearing damage could be regarded as the tip of the iceberg in terms of effects associated with noise. There were certainly many minor physical and mental ailments which, if not caused by noise, were certainly exacerbated by it. The question was how to establish the exact relationship between the symptoms of ill health and levels of noise in the general environment or in the workplace.

Part of the difficulty lay in the research. He would certainly not deride research, having spent forty years of his own life engaged in that activity. However, he described it as a cottage industry, and self perpetuating. The difficulty lay in getting research applied. It was always difficult to secure agreement among the technical experts about the suitable application in the real world of research findings; and the bureaucrats, who were themselves no fools, seized upon the divergencies of opinion to back up their view that too many problems lay in the way of taking any concrete action.

The whole dilemma was beautifully illustrated in a series of papers in the Journal of the Acoustical Society of America, one of which, by Botford, was entitled "The Waiting Game"; this showed the long time lapse between the measurement of aircraft noise, the measurement of social response in terms of stress, ill-health etc and the establishment of a noise limit. Botford showed that "The Waiting Game" consisted of arguments about how the aircraft noise frequency components and durational aspect should be given relative weightings: a problem of weighting resulted in a problem of waiting - for appropriate regulations. Although anecdotal evidence could be alarmist and it was not very reliable, research too was fallible. Researchers had such a limited understanding of the problem that they were tackling, that the results were often confusing and of limited value.

However, Dr. Langdon wished to draw attention to one particular aspect of the "iceberg" of the wider effects associated with noise. This was the stress and tension to which people were subjected as a result of exposure to noise. This could send them to their doctor and fuel the demand for drugs, in particular valium. Dr. Langdon considered that valium dependency was a problem on a far wider scale than heroin dependency, and an addiction that was even more difficult to break.

MR. M.J.T. SMITH, replying first to the point about the prospects for a 1,000 seater jet aircraft, believed that it would be a reality in time, although not in the immediate future. Industry could produce one tomorrow if the demand were there. The point was whether 1,000 people wanted to be moved to the same place at the same time. A greater number of smaller aircraft provided the public with a greater element of choice as to when they made their journey. Regarding the legal control of noise, a 1,000-seater aircraft would never be allowed to produce any more noise than the current largest plane, the 747. This implied a need for improvements in the technology of noise control.

The second question had concerned developments in jet engine noise control and the possibilities for their wider application. Unfortunately, the jet engine used in aircraft was unique. Although gas turbines were used elsewhere in industry, eg for gas and oil pumping, and it was possible to use normal standards of technology to suppress the noise from those units, unfortunately the research and development work that Rolls-Royce did was largely concentrated on the aircraft jet engine. There were technological spin-offs such as the acoustic liners. These could be used elsewhere, although they would rarely be required other than in the ductings of a jet engine due to their complexity and cost. Detailed information on turbo machinery research was also of little use to anyone engaged in manufacture of domestic or industrial heating and cooling systems with fans in them - those simply were not the high speed, high energy types of device that were used in jet engines. But odd bits of information in that research would have wider application if they were taken note of.

MR. M.J. GITTINS said that Mr. Dawson had raised a number of interesting points. He turned first to the question of the role of audiometricians in court cases where there was a question of how someone came to suffer hearing damage. The significance of that point could be appreciated from the study of the research carried out by John Bickerdyke, who had found it very difficult to find students who only received noise exposure from a single source. From memory, Mr. Gittins recalled that about 25% of the students also used firearms. Adding that exposure to entertainment noise, the total of leisure noise received by the students amounted to something like 94 dB(A), which was equivalent to four hours' industrial exposure. When somebody was already exposed for eight hours to a significant level of industrial noise, with the leisure noise element on top, then the problems began to emerge.

Turning to the anecdotal evidence supplied by Hylton Dawson, about the effects of visiting a disco the night before, Mike Gittins said that observations taken from standing outside a disco showed that during the course of the evening the noise level tended to rise about 5-8 dB(A), perhaps to compensate for the small temporary hearing loss experienced by the clients inside the disco. But if an EHO entered the disco with a sound level meter, the noise levels dropped instantly by about 15 dB(A)!

CLLR. MRS B.J. SOLKHON (Brighton Borough Council), mentioning the old saying "Get them young and treat them rough", felt that it had been turned on its head recently. The young were treating the wider public roughly by the use of ghetto blasters and personal stereos (a misnomer since so much noise leaked from the small headphones to disturb other people in enclosed spaces such as railway carriages).

She had missed a reference in the papers presented to the vital need to educate young people about the dangers of noise and the need for social responsibility in their own behaviour. She was now convinced that loss of hearing was essentially cumulative or progressive. Thus, if people embarked on work in a noisy industry following a fairly mispent youth listening to loud music in discos or through personal stereos, then they could be laying themselves open to serious hearing loss. She asked for suggestions from the speakers as to ways in which to get the message across to young people. Children were educated in schools about the dangers of drugs and about the need to avoid smoking, but she wondered whether the NSCA or any other group was taking steps to ensure that there was an educational programme about noise.

It was not only the young people that needed educating, but the noise producers themselves, as those who had attended the recent IEHO Congress knew. At the dinner there, the noise from the band had been so loud that several requests had been made to turn it down. The band refused to comply, saying that that was the level of noise output that people liked!

MR. GITTINS said that although he had not touched upon the role of the local authority as an educator in his presentation, he had referred to it in his written paper. As he saw it, there were two separate but related roles. First was the responsibility that all those involved in environmental health had for educating the public at large. Through various Environmental Health Departments, through the Health Education Council and even through the Central Office of Information (which made almost any message sound boring), the message was put across to the wider population.

But the local authority also had a particular role in relation to youth and other activities carried out on council premises; here, it was more than simply a matter of education. The responsibility of the local authority might also lie in ensuring that hearing damage could not result from activities carried out on its own premises. It should impose controls in establishments for which it had an operating responsibility, so that it could not be held accountable, directly or indirectly, for any form of hearing damage. Then, as John Bickerdike had suggested in his draft Code of Practice on disco noise, notices could be posted warning that "excessive noise can damage your hearing". Mr. Bickerdike had also advocated the provision by the relevant local authority of leaflets explaining the effects of exposure to over-amplified sound in discotheques, these to be made available to the clients. Mr. Gittins so approved of Mr. Bickerdike's wording in his draft leaflet that he would have put it in his own paper, except that he did not wish to pirate another man's work. He summarised the situation by saying that some people were thinking very deeply and carefully about solutions to the problem. What was lacking was the central, co-ordinating initiative to promote effective solutions.

CLLR. J.C. BLEWITT (South Oxfordshire DC) said that he had worked in the motor industry for 36 years. Within 12 months of leaving it, he had discovered that he had lost 30% of his hearing. While a Code of Practice existed, all the national regulations were only as good as the finance available to enforce them. He considered there to be a good case for central government funds to be made available for this purpose, possibly to local authorities.

Turning to the papers, Cllr. Blewitt had interpreted the presentation by Dr. Langdon as indicating that there was no real health problem as a result of exposure to noise.

However, he felt that Mr. Gittins had showed clearly that such problems did exist. In fact, Cllr. Blewitt considered that the link between noise and health had been established many years before. He was surprised that a public education programme had not emerged but he considered that, again, central finance was necessary to enable local authorities to carry out such educational work at local level. He considered that the NSCA should keep up the pressure on Central Government to ensure that the finance was available so that local authorities could carry out this essential noise control education, enforcement and advisory service. The Health and Safety Executive had the task of enforcing noise control in industry, but once again they were only as effective as the resources available to them. Already, manpower levels had been reduced by central government policies and he was concerned that this could lead to a decline in environmental health standards in industry. He considered that government were putting cost before the health of the nation.

DR. LANGDON said that he would not disagree with those sentiments in any way. The only question perhaps was where to put the money and resources so that noise control could be most effectively applied, but he did not think that those concerned to see some improvement ought to have to demonstrate to government that this or that area would show the best results before such fundings were made available. In his judgement,the whole field of environmental pollution control had taken a back seat in the past ten years. He felt that the question of gaining financial support for more effective noise control was related to the far wider issue of support for the human and natural environment, and the strength and power of local authorities. He did not think that the problems of effective noise control could be separated from these wider issues. It was part of a general malaise, from which the whole of Western Europe was suffering, although the UK was perhaps suffering more acutely than any other Western European country. Basically, it was a political question.

MR. SMITH said that as far as aircraft noise control was concerned, there had been a raft of legislation in the past 10 to 15 years. The problem with legislation was that it often occurred at the wrong time - ie too late - or that once on the Statute Book, it was developed in unfortunate ways. With aircraft, it took approximately 4 years to design and develop a new aircraft. This would then be in service, either in its design or secondary developed form, for 30 or 40 years. Legislation, on the other hand, made assumptions about what the pattern of aircraft would be in 10 years' time. To that extent, it acted too quickly. There were still those who wished to make legislation ever tougher, even at this stage, ignoring the fact that only 30% of the world aircraft fleet actually had in its structure modern, quiet technology. It would be ten years before the success of that technology could be measured, so that the case for the application of tougher standards straightaway was probably quite unrealistic.

Reference had been made to the Noise Advisory Council (NAC). While Mr. Smith regretted the demise of that body, he said that one of the problems with it had been that the process of promulgating recommendations had taken so long that, in the meantime, technical developments had in many cases overtaken the reports which were eventually put to Ministers. If the NAC had been a thrusting organisation, producing its recommendations in a timely manner, it might not have been scrapped. Mr. Gittins agreed with the thrust of Cllr. Blewitt's comments. He said that the NSCA recognised that it had an important role as an educating body, and that it intended to develop that role in relation to young people. Hylton Dawson had written a very good book on noise which was published by the Society and aimed at the general adult public. The Noise Committee might possibly examine the ways in which packages of material could be developed for younger people.

CLLR. MRS.E.E.PITT (Walsall MBC) said that noise pollution was an old problem, dating back well before the advent of the jet engine. For centuries people had experienced noise problems, as the Bible demonstrated in the passage about the fall of the walls of Jericho,

> "So the people shouted when the priests blew with trumpets, and it came to pass the wall fell down flat." (Joshua, Ch.6, verse 20)

Councillor Pitt said that when she had read Dr. Langdon's paper, she had wondered whether he still worked for a government department: in places, the paper had seemed to indicate that noise did not present much of a problem. On page 6, the paper had quoted Thompson, F.J.(1985) as follows:

> "... There is no definite evidence to prove that noise is responsible for cardiovascular disease or hypertension."

Cllr.Pitt wondered what type of authority Thompson was - whether perhaps he worked for a government department. What had not been clearly brought out in the presentation was that all sound consisted of vibration, which affected the whole body. Thus, a deaf music student could successfully study at the Royal College of Music and give public performances, because the notes, eg the loud bass notes from a piano, vibrated on her legs. In China and ancient Egypt, music had been considered a science and the ancient people appreciated power.

Turning to pop concerts, she referred to page 12 of Dr. Langdon's paper, in which he had written:

> "At the same time, study of exposure to live and recorded pop music has not revealed anything that can yet be described as a menacing phenomenon."

At one time in America there had been a craze for balancing live eggs on the stage during pop concerts. Half way through the concert, the sound had congealed the protein so that the eggs were cooked ready to be eaten. Cllr. Pitt felt that such physical effects were worrying.

She considered that the papers had been slanted towards the hearing impairment angle, and had not considered the beneficial effects of noise on health. She referred to the work of Guy Manners at the Bretforton Clinic in the Vale of Evesham where Cymatics was practised. Working on the basis that every organ in the body had its own frequency, Guy Manners used sound impulses to stimulate organs and tissues, to restore them to their healthy frequency. Cymatics was a term originally coined by Dr. Hans Jemy who had transferred sounds in patterns in liquids, metal filings and powders. The original work in the field had been carried out by Ernst Chladni, the German physicist whose figures had displayed recognisable stripes, spirals and other patterns familiar in nature. Cllr. Pitt wondered why no reference had been made to this work in Dr. Langdon's paper.

Finally, she asked the speakers what type of research into noise the panel would wish to encourage, and what further government legislation they considered necessary to bring about tighter control of noise pollution.

MR. GITTINS, answering Cllr. Pitt's final point, said that he would like to see the introduction of the draft Code of Practice on Discotheque Noise, and further examination by the Society's Noise Committee of priorities for action.

DR. LANGDON considered that the points raised by Cllr. Pitt were personally held points of view and he did not wish to enter into a debate on that basis. He considered that the conclusions he had presented represented the balance of the general tenor of conclusions from present international reports, such as those of the International Commission on Noise as a Biological Hazard (the Torino Conference), the Zurich Hearing Conference of 1983, the recent report by the Institute of Hearing published by HSE in the UK, and similar documents. No one denied that noise was a problem and that it produced health effects. But it was necessary to identify what precise effects it had, where they fell and what measures were necessary to counter or treat those effects. That stage of precise identification was far more controversial.

The paper concluding the Torino Report on Noise and Health, which was by Thompson who was from Virginia University, pointed clearly to the fact that nearly all the work done in that area was of such a low technical level (certainly, in the case of the epidemiological and medical studies) that it was very difficult to draw firm conclusions from any of the studies. Dr. Langdon had forborne to quote that passage, since it appeared so pessimistic that it might depress people. But such a respected opinion had to be taken into account. It was essential to improve the technical quality of research work in order to provide good ammunition for such bodies as the NSCA to use.

MR. R.C. WEBSTER (Leicester City) asked Dr. Langdon to expand on his points about the indices used to assess sleep disturbance. The paper had mixed Leq and Ln - he wondered which index Dr. Langdon thought preferable given the peakiness of noise and its effect, or whether Dr. Langdon would prefer that a new index be derived which would reflect the peakiness better.

In addition, all the units in the paper were dB(A). Dr. Langdon had referred to the effect of traffic noise after sound insulation had been carried out, but as was well known, double glazing still allowed the lower frequency noise to penetrate and this was not well reflected by readings expressed in dB(A). He asked whether another unit, such as dB(Lin), might be preferable.

DR. LANGDON said that measures of peakiness had been tried in addition to the equal energy measures, but it was eventually necessary to show that incorporating such measures resulted in a better statistical representation of the variabilities than if they had not been incorporated. Adding one more variable to take account of peakiness did not seem to do that satisfactorily. The broad range of measures could be used in the laboratory situation when testing the effects of noise with all its peakiness on the quality of sleep enjoyed by selected subjects. But for the purposes of regulation when dealing with the broad statistical population, such variance was not readily incorporated.

On the second question about dB(A), Dr. Langdon agreed that it would ideally be desirable to take account of all parts of the noise spectrum, particularly when dealing with double glazing or sound barriers, which produced differential attenuation and resulted in dB(A) diverging from the sound spectrum actually received. Although they had considered the matter deeply, the general consensus among scientists and acousticians was that since it had taken 30 years for dB(A) to be widely accepted and used, throwing it overboard might mean that another 30 years could elapse before agreement was reached on another unit. In summary, it was preferable to stick with dB(A), with all its weaknesses.

MR. J. EVANS (Rhymney Valley DC) said that he had found all three papers extremely interesting, and considered that all the speakers should be congratulated on their presentations and the quality of their work. Turning specifically to the presentation by Dr. Langdon, Mr. Evans said that he had found it extremely disturbing that schoolchildren in the USA already experienced exposure, on a daily basis, to 80-85 dB(A) Leq. He wondered whether comparative UK data existed.

Such information reinforced his belief that the Society had a very important role to play in enhancing the education of the general public on noise matters. As a member of the Noise Committee, he was aware that the NSCA's Information Department was currently preparing a teaching pack on noise for use in primary schools, which would come complete with a set of teacher's notes. He hoped that the Noise Committee would expand its activities to include still more information for the education of the general public.

Mr. Evans said that he had noted with interest the comments on the relationship between noise exposure and cardiac hypertension. Although the American literature review had concluded that there was no definite link between noise exposure and cardiovascular disease, he agreed with Dr. Langdon that the situation required clarification. Further studies were being carried out: one particular study was being carried out by the MRC in conjunction with his own authority, which was an area of very high incidence of cardiovascular disease. The Rhymney Valley DC / MRC study involved particular subjects wearing noise dosimeters throughout the day. Noise measurements were being carried out in the workplace, in the home and in areas where the subjects were exposed to traffic. The aim was to compile a complete dossier of the noise exposure of certain individuals. He knew that German scientists had collaborated with the MRC in such work, and he wondered whether Dr. Langdon knew of any published findings or reports.

Mr. Evans had found the consideration of the acoustic effects of double glazing very interesting, and had been unsurprised by the observations made in the Dutch study, that the peak noises remained just as disturbing. In fact, it occurred to him that the installation of double glazing could, in certain circumstances, produce effects quite opposite to the introduction of white noise in some offices. The aim of introducing white noise was to increase the background levels so that peaks went unnoticed. He asked what conclusions Dr. Langdon would draw from these conflicting circumstances and whether the quality of double glazing installations should be improved.

Reference had been made to the demise of the Noise Advisory Council, and Mr. Evans considered that the NSCA's Noise Committee was to some extent filling the gap; in conjunction with work done by the Institute of Acoustics he considered that the gap could be totally filled and thus the government would benefit from high quality advice without being required to fund the work.

DR. LANGDON, who could not on the day catch all that Mr. Evans had said clearly enough to feel confident about replying to the questions, subsequently sent in a detailed written reply which is reproduced on pages 60 - 63.

CLLR. B.R. FITCH (Brighton BC) asked first whether earplugs might be used to help protect hearing in discos.

His second question related to the children, aged under 16 years, who drove small motorbikes without licences or being subject to any controls whatever, scrambling on patches of land throughout the countryside and sometimes in areas close to towns. There was a particular problem when the "teeny" motorcycles were ridden in valleys, as the noise ricocheted from side to side and caused extreme disturbance to nearby residents. From the safety point of view, ramblers and other walkers using the countryside were at risk from the activities of these very young, untrained riders. In effect, children were being permitted to drive machines that could kill people - either themselves or others - and at the same time were causing general disturbance and distress to all inhabitants of the countryside - human and animal. Cllr. Fitch asked the speakers whether they considered there was a case for legislation to be introduced to control such activities.

MR. GITTINS doubted that earplugs were any solution to the problem of disco noise. The only practical solution was to design the premises so that they intrinsically minimised the risk of high noise exposure. Clients in discos wanted to listen to high levels of noise, so were unlikely to protect their hearing with earplugs.

On the second point about motorcycles, Mr. Gittins entirely agreed that there was a need for control not only in the class of bikes to which Cllr. Fitch had referred, but also the indiscriminate use of rally and cross-country bikes which were not designed for use on the highway and therefore not required by law to have the same level of silencing as standard licensed motorcycles.

MR. SMITH said that all the legislation in the world was pointless without adequate policing and enforcement. Living next to a main road in a village, Mr. Smith found that motorcycles howled up and down the road outside his home at all hours and, as far as he could tell, were virtually unsilenced. Under legislation, those motorcycles had to be manufactured to meet certain noise limits for the exhaust/silencer system. But it was essential to police the situation once the bikes were in use, and prevent tampering with the silencer and noisy driving habits.

MR. G.H. VULKAN (Greater London Council, Scientific Services Branch) felt that in its broadest sense noise annoyance was related to health and wished first to highlight the importance of people's subjective reaction to noise - their attitude - which coloured their perception of the problem and was sometimes ignored in assessments made of the effects of various sources of noise. He asked Dr. Langdon whether he considered that insufficient attention had been paid to some of the non-acoustic factors connected with noise annoyance. For example, there could be more resentment against motorcycle noise than against car noise at the same level, because motorbikes were perceived by some people to be more "anti-social" than cars. The possibility of danger from a source of noise could heighten the reaction to it, while, conversely, an awareness of the benefits associated with another source perhaps lessened the strength of the reaction. In the past, evidence had shown that people living near an airport who were themselves employed by the airport authority or by an airline were less likely to be annoyed than those who were not so employed.

His second question was specifically directed towards aircraft noise. He believed that there had been an improvement in recent years in the level of noise from fixed wing aircraft, but helicopter noise was becoming a problem of increasing concern, certainly in central London and probably in many other cities. There had not been the same improvement in terms of reductions in levels of noise from helicopters. He asked Mike Smith to comment on the future prospects of achieving substantial reductions in levels of helicopter noise.

MR. SMITH said that helicopters were still comparatively rare. The main problem was with their operation. The altitude and flight path of the helicopter link between Heathrow and Gatwick was tightly controlled. A helicopter's noise path was rather similar to a train, being narrow but long, and thus there was a great deal to be gained by the proper operation of the helicopter. Nevertheless, there was a great deal of research going on into quietening helicopters at source. This was not an easy problem to solve. He believed that more was to be gained from encouraging an enlightened view as to how they should be operated.

DR. LANGDON, replying to the question about non-acoustic factors in annoyance, said that his brief had been to speak on noise and health and he had not so far mentioned annoyance since he did not think that this bore any relation to health effects. He questioned whether in fact it was desirable to include non-acoustic factors. A great deal of research had been done in that area, assessing people's reaction to the quality of the environment, their attitudes towards the authorities responsible for securing that quality, etc. Adding in these non-acoustic factors helped researchers to account for their results. Looking at noise as a factor in annoyance, people had a very specific reaction to it. They considered that it was possible to control noise; given that these technical means existed, the question then was what it would cost to control the noise and by how much the noise level had to be reduced. However, many of the non-acoustic factors in annoyance could not be tackled in this way. People had no direct control over them. In Dr. Langdon's view there was no point in including within standards factors over which people had no control.

Thus, it was necessary to make a distinction between including non-acoustic factors in the equation which researchers derived when studying the relationship between annoyance and measured levels of noise, and the drafting of regulations. In the latter case, inclusion of non-acoustic factors would be of very little use, whereas in the former case their inclusion would help to strengthen the scientific model which the researchers were deriving. It was the difference between research use and practical use. In the case of regulations, inclusion of non-acoustic factors would not be practical because it was impossible to tell what their value would be at the point at which regulations were being applied.

MISS JANE DUNMORE (NSCA) closed the session by speaking of the education pack on noise which was being prepared by the Information Department under the auspices of the Society's Noise Committee. The pack was complete to draft stage, but funding was required to produce a final version and, in particular, to design and commission the production of the wall-chart which was an essential component of the pack. She made a plea for sponsorship from whatever source, and to whatever amount.

DR. J. LANGDON

Replies to points raised by Mr. Evans of Rhymney Valley DC

I found his comments very interesting and agree generally with the tenor of his remarks. As regards specific questions I would answer as follows:

1. Noise exposure of American schoolchildren. I agree, it sounds rather high, though a

similar study carried out in Sweden and reported by Dixon Ward in his paper to the Torino Conference 1983 (included in references given in the written paper) gives a similar figure. Not having read the paper by Cohen et al (1980) from which this figure was taken, I am unable to comment as to whether the method of measurement employed might have resulted in an abnormally high value. I think this unlikely, however, since in this case Ward himself would have pointed it out. On the other hand, a study by Schori & McGatha (J. of Sound & Vibration, 1978,12,24-30. "A real-world assessment of noise exposure") gives a figure for the general US population of 80 dB(A) for a daily 8 hour period. So far as I know there is no comparable UK data, though it is possible that some information might be forthcoming from the National Institute of Hearing at Nottingham who are engaged on a large-scale UK epidemiological survey of hearing thresholds and acuity levels. I personally doubt whether the 85 dB(A) figure could be regarded as dangerous. A great deal of this noise would arise from the children themselves (that is one reason why I am loathe to comment on Cohen et al, since the children may have been carrying dosimeters on their persons). 85 dB(A) is regarded as an acceptable maximum in industry for a daily 8 hour period, taking into account the restoration of the t.t.s. which will take place during leisure and sleep. Nor is there any evidence that children's ears are more susceptible to damage than those of adults - though cumulative loss beginning earlier would result in greater impairment by a given age (if it occurs). It will be seen how complicated the topic is and how difficult to come to firm conclusions!

2. Individual noise exposure. I am not aware of the German work. I know of one reported

study of 30 workers by the French Institute of Transport Research in Lyons, and of a Japanese study of some 600 persons. However, such results have to be scrutinised very carefully since the difficulty of making a personally worn dosimeter run for long enough to go through the waking day is considerable, and in addition the person carrying it has to provide a daily diary of activities to enable the sounds to be identified.

3. The improvement of double glazing. Frankly I doubt whether acoustic double glazing can be much improved. The maximum theoretically attainable attenuation over the major part of the spectrum (leaving out low frequency noise which is rather poorly attenuated) is likely to be not much more than 35-38 dB(A). Where outside levels rise to as high as 87 dB(A) or even more, the internal level will then be nearly 50 dB(A). The Wilson Committee (and most other authorities) concluded that the internal level for bedrooms should not exceed about 35 dB(A). This also disposes of the suggested solution of added white noise. White noise has been found useful in offices where it masks peaks and helps to preserve privacy. But this is in a situation in which people are trying to work and converse, not go to sleep. The experience of researchers from the Building Research Establishment, who were responsible for the development of acoustic protection to bedrooms in homes around airports and near motorways, has been that it was essential for the ventilation fan in the acoustic air filter provided to make less than 38 dB(A) or otherwise the (would-be) sleeper was disturbed. Regrettably, the only satisfactory solution to noise in the bedroom is either (i) having the bedroom on the side of the building away from the source (impossible for aircraft noise),or (ii), reduction/removal of the source, or

finally (iii) more effective planning. The problems of designing double glazed acoustic windows are very great - to say nothing of the fact that their effectiveness will decline as the seal between the frame and the surrounding structure breaks down, as it always will over time, through the action of changes in temperature and hummidity.

Speakers: D.V. Jackson and W.L. Hall

DR. F.E. SHEPHARD (British Gas Corporation, Research and Development Division), opening the discussion, recalled the shift in public opinion in the 1970s, when waste ceased to be regarded as a nuisance and instead was looked upon as a valuable or potentially valuable commodity. He had found the presentations very helpful in bringing him up to date with developments in the state of the art concerning refuse-to-fuel technology. Indeed, both papers had been very optimistic in tone on the prospects for energy from waste, and he considered that this reflected the enthusiasm and hard work of the authors and their respective colleagues, as well as that of the organisations that had taken the plunge and installed the technology.

One thing to be regretted was that in the necessary separation of materials, not all the components of waste, in particular the metals, could be put to use once more.

The paper by Jackson and Tron had given several examples of successful applications for shredded and pelletised waste, but it was clearly necessary to ensure that the material was of adequate quality and that combustion was carefully controlled. He had been surprised by the figures which compared the price of refuse-derived fuel with gas and coal, and indeed by the apparently very favourable payback period on investment in the necessary plant - 2 and 1/2 years. He wondered whether these figures, prepared by ETSU, were perhaps rather misleading. He asked whether the quoted costs covered the collection, separation, shredding and other treatment of the material before it could be used, ie whether the customer had to pay for that treatment as an extra, or whether the ETSU figures included those costs and were truly comparative.

Some problems of potential emissions and combustion control had been referred to in both the papers and the presentation. Additives had been suggested as a possible solution, but Dr. Shephard considered that one of the advantages of RDF was its simplicity in use. A requirement to use additives, eg to control chloride or other constituents in the ash, would complicate the process and perhaps push the costs up to an unattractive level.

Passing reference had also been made to the possible impact of future legislation. Dr. Shephard was unsure whether this referred to the cadmium and mercury that Mr. Jackson had specifically mentioned, or whether Mr. Jackson suspected that organics might be controlled under future legislation. He asked the author to expand on this point; in particular, on how he thought future legislation might affect the market for the fuel.

Turning to the paper by Mr. Hall, Dr. Shephard said that it had given him a good understanding of the processes involved in the generation and harvesting of methane. He suspected that there might be a conflict between the needs of the landfill operator, who would presumably require rapid depletion and a quick payback period, and the consumer of the methane who would want the longest payback period possible. He wondered whether there were marketing advantages in trying to design the landfill site, or adjust existing sites, to alter the half life of the methane generation.

Both papers had highlighted the need to find suitable markets for the fuels. One of the successful applications referred to in Mr. Hall's paper had involved a 5 km pipeline. Dr. Shephard wondered whether there was an economic radius for the uptake of the fuel generated. He asked whether the availability of methane at a particular site had actually attracted potential customers to the area or, in Mr. Jackson's case, to an area where pelletised fuel was being prepared. He doubted whether there would always be an existing customer waiting to use the extracted methane or the pelletised fuel.

Mr. Hall had referred to an investment requirement of half a million pounds and Dr. Shephard wondered whether he too could offer a two and a half year payback period. On the face of it, the investment figure looked attractive.

As an aside, Dr. Shephard thought that Mr. Hall had been rather pessimistic in referring to his project as one of the rare examples of co-operation between nationalised and private industry. British Gas had done their best to help their private industry customers and for many years had worked closely with private industry in trying to reduce their fuel costs, via the gas energy management (GEM) awards scheme.

Energy from waste had been in the news recently. Dr. Shephard had heard that the Edmonton Plant was beginning to reap the benefits, in terms of income, from the electricity it had generated. A recent letter in The_Times had complained that the UK wasted the equivalent of £1 million per day by not exploiting the potential of waste to the full, and stated that Britain was well down the league of nations in this respect. He congratulated the authors for throwing more light on the technology and the advantages of refuse derived fuel and considered that their presentations might help the country to move up in the chart of nations making practical use of refuse as an energy source.

MR. D.V. JACKSON made it clear that the total output of fuel from solid waste would not make significant inroads into the market for gas as supplied by British Gas! As to costs, those quoted in the paper certainly did not cover the cost of collection. It was assumed that waste would have to be collected in any event. However, the figure quoted covered all the processing costs, and a key factor in the economics was the alternative disposal cost which was usually the dominating factor in whether or not the system was economic.

He emphasised that the costs quoted referred to the shredded waste system installed on Humberside and used by Courtaulds. In this case, the user would take as much fuel as the supplier could provide. This resulted in minimum processing costs to derive a fuel which was immediately marketable. Thus, it was a very favourable situation, but they were true costs. The costs were very similar to those of Blue Circle, where again there was a tied system, with the fuel going straight to the user, into the kiln. He entirely agreed that simple systems were the best, and that was reflected in the costs for the direct tied-user system.

Whether or not the market would bear modifications to the pelletised fuel (ie to improve combustion efficiency or reduce eventual emissions) was essentially a question of economics. The answer was not known, but the more R & D work that was carried out, the more it was possible to reduce the costs of the fuel. Unless waste derived fuels could compete with other fuels in terms of price, they would not be produced. At present, there was some demand from industry for the fuel since, as a result of demonstrations to date, industry could see benefits to be derived from the cheaper fuel.

As to organic emissions, these would depend on the quality of burn-out. Providing the fuel was used properly and efficiently, with due attention being paid to the primary and secondary air regimes, then organic emissions should not be a problem. A paper had recently been presented at the International Union of Pure and Applied Chemistry, in Manchester, with the title "All Pollution is Caused by Analysts"! To some extent, this was a true reflection of the ability of the greatly improved modern analytical methods to detect minute trace quantities of organic material in any combustion derived emissions - coal, as well as waste. Modern chromatography could reveal approximately 350 different organic materials in the emissions. However, any pollution was kept to a minimum providing the burn-out was right. He was not complacent on the subject, and Warren Spring were continuing to look at this question but on the basis of present evidence he did not think that the implications were worrying.

He had been most interested by Dr. Shephard's reference to the profits now coming in from the Edmonton Plant, and the recent letter in The Times. For the benefit of those unfamiliar with the Edmonton Plant, he described it as a massive incinerator which was acting as an electricity generator, fired by waste. It was the cheapest method of waste disposal in London. However, the plant had been paid for many years before. Today, a very considerable investment would be involved and, while he understood that the GLC were investigating the possibility, he did not know whether it would prove to be economic. As to the letter in The Times, he did not welcome the injection of emotive arguments into the promotion of fuel from waste but preferred the case to be made on the basis of hard facts and straightforward economic advantage.

MR. W.L. HALL wished first to address Dr. Shephard's points about the potential for landfill gas. The Energy Efficiency Office of the Department of Energy (the Energy Technology Support Unit - ETSU) had prepared estimates on the quantity of biogas or landfill gas used to commercial and industrial benefit in the UK. The Aveley Plant supplied about 20,000 tonnes of coal equivalent per annun. He estimated that the immediately accessible potential was about 400,000 tonnes of coal equivalent per year, and the Department of Energy were looking to achieve 1,000,000 tonnes of coal equivalent a year, which would equate to 1% of the coal industry's output, which was a not insignificant amount of energy, for the future. The total quantity being tapped in 1985 was between 30 and 40,000 tonnes of coal equivalent. Aveley was the single largest successful scheme; there were some small and very successful schemes, and others would be coming on line in the next few months.

As to the possible conflict between the demand by the site owner for a rapid depletion/rapid payback and the user's need for slower depletion and a longer payback term, Mr. Hall claimed that landfill gas had so far in the UK been tapped only from completed or nearly completed landfill sites during the six to seven years in which this type of energy recovery had been operating. So far, landfill sites had not been designed with gas collection and use in mind. He believed that this development would occur, possibly within two or three years' time. As he had mentioned in his paper, one of the main controlling factors in the output of gas from a landfill site was the amount of water present in the site. Very wet sites led to rapid generation of methane. Thus, in order to control the generation, it was necessary to adjust the water content of the site either by controlling ingress of ground water or by covering and protecting the site from rainfall.

Another route currently being explored by the GLC and NSF was biotechnology, involving the selective exploitation of bacteria - seeking to encourage those bacteria which produced methane in preference to other gases. The Aveley venture had invested some £100,000 in a three-year project aimed at identifying the strains of bacteria which produced methane at different levels in the site and the strains of bacteria which were most active, cultivating those bacteria outside the site and then re-injecting the site with the cultivated bacteria to enhance the conversion. This research would ultimately have benefits both for the site operator and for the user who would be supplied with greater quantities of cheap energy which could displace conventional, more expensive fuel.

Regarding the market for the fuel, Mr. Hall emphasised that the economics of the site were totally market driven. It was essential to have potential users near to the site and a preliminary step was to identify the market in terms of customers. The yardstick for colliery methane was 1,000,000 therms (4,000 tonnes of coal equivalent) per mile and the same sort of yardstick had to be applied to landfill gas in order to ensure reasonable payback on investment. To date, industry had not been attracted into the vicinity of landfill sites by the prospect of cheap energy. Great attempts had been made to draw industry into areas where fixed sources of gaseous energy were available but so far, due to the state of the economy, there had been no success in the efforts to persuade energy-intensive heavy industries to move to landfill gas production sites. Indeed, industrial recession had put paid to many of those energy-intensive users.

Referring to the total costs and payback period for the Aveley scheme, Mr. Hall said that, given the initial capital outlay of £1,500,000, income was £1,000,000 per annum and, taking into account operating costs (principally manning, power and maintenance), the payback period was less than 3 years. For a more typical smaller scale site, such as the Merseyside site, the investment was approximately £500,000 for an income of £300,000 per annum. Unfortunately, the investment did not decrease linearly with size, and so the payback period was slightly longer. However, he was confident that landfill gas developments would show an attractive return on investment capital and would draw money into the industry. Investment so far had been not from rates or other public sources of money, but from private capital. The money had come from merchant banks via loans or leasing and investment was available for schemes that had secure and short-term payback on capital.

MS. JANE BRICE (Greater London Council,

Scientific Services Branch) referred to the growing concern over the emissions of dioxins and furans from the incineration of municipal refuse. Bearing in mind that many of these incinerators were sited in densely populated urban areas, and remembering also that the operating temperature might not always be sufficient to destroy the dioxins and furans, she asked what opinion Mr. Jackson had of the implications for the local community, and on what that opinion was based. She asked further whether Warren Spring Laboratory had planned to carry out research in this area, and requested details.

MR.M.J.COOKE (NCB, Coal Research Establishment) asked Mr. Jackson whether the storage and handling of RDF pellets had any implications for the health of the workers involved, and if so, what precautions he considered should be taken.

MR. W.F. HERON (Brighton BC), referring to Mr. Jackson's remark that RDF was in its infancy, said that it followed, therefore, that the operators' knowledge of emissions and environmental health departments' experience of applying the Clean Air Acts to those emissions were also limited. His own experience with the Easiburn fuel in East Sussex was that the County Council were using the fuel for the heating of schools and colleges - a very local use. He had received a proposal to convert from oil firing to RDF fuel on the boiler of a local college. In his view the applicant's knowledge of the implications in terms of emissions had been inadequate. There had been no proposal to increase either the chimney height or the efflux velocity, nor had there been an intention to fit grit and dust arrestment plant. Consulting the usual sources of information, such as the Memorandum on

Chimney Heights, Mr. Heron had found the data inadequate. Fortunately, he had found the necessary help when he consulted the air pollution division of Warren Spring Laboratory. But this consultation had come almost too late.

Saying that other local authorities in East Sussex had experienced similar problems, Mr. Heron asked Mr. Jackson what more Warren Spring Laboratory could do to alert local authorities to the problems associated with the burning of RDF, and to encourage proper administration of the Clean Air Acts via dissemination of relevant knowledge.

As a short supplementary question, Mr. Heron asked whether the composition of RDF varied sufficiently to need taking into account when considering the height of chimneys.

CLLR. R.J. KIDD (Newtownabbey BC) said that the development of gas for Northern Ireland had been halted by the failure of the NCB to take on the competition from oil. As to waste disposal, landfill was held to be the cheapest method. However, as practised in the Belfast Lough, landfill was a disgrace. He wondered whether the waste generated by approximately three-quarters of a million people would make methane from the landfill site a worthwhile venture. Cllr. Kidd said that the presence of gas at the site could be assured from the death of most fish and plant life.

Secondly, he wondered whether using waste as a direct fuel - either shredded or pelletised - was more economic than recycling various valuable elements in the waste such as glass, paper etc.

CLLR. MRS. D. DUNLOP (Belfast City Council) explained that Newtownabbey BC had requested the use of Belfast Lough for disposal of waste to landfill. Newtownabbey BC had in fact been prepared to pay Belfast City Council a considerable sum of money for this method of disposal. She considered that if Cllr. Kidd had been concerned at this use of Belfast Lough, he should have used his influence with his own Council to prevent Newtownabbey's waste being disposed of in that way.

The present position was that, in the interests of the environment, the Belfast City Council had actually voted against taking Newtownabbey's waste and disposing of it to Belfast Lough.

MR. D. PERRY (Gloucester City Council) asked Mr. Jackson whether the presence of 25% putrescible materials in the waste used to make pelletised fuel resulted in an odour problem during the drying which was part of the pre-treatment process, in the same way that the drying out of such material gave rise to odour in the animal by-products industry.

MR. R.A.B. HALL (Greater London Council) wished first to congratulate both speakers on the excellence of their presentations. He said that the GLC and NSF had been in very successful partnership at Aveley for three and a half years. He endorsed everything that Mr. Hall had said about that scheme. Unfortunately, the Government's plans for the abolition of the Metropolitan County Authorities had placed rather a strain on that relationship.

In parts of the United States, up to 1% of the mains supply of gas was made up by supply of landfill gas. He asked Mr. Hall whether he saw any prospect for a similar feed of purified landfill gas into the UK mains gas supply.

Turning next to the paper by Mr. Jackson, he welcomed the prospect of expansion in the use of RDF but highlighted the need to ensure that the chimney effluent satisfied the law and met the requirements of public health standards. He asked whether the gas cleaning processes for both mass incineration and pelletisation plant had improved in the course of time and what measures were being taken in the West Midlands and Merseyside Plants - the very new generation WDF plant - where they were planning to burn some of their own pellets to provide the heat necessary to dry the pellets. He asked whether such measures were sufficient to satisfy the public living in those areas.

MR.J.R. TEALE (Institution of Gas Engineers) requested further details about the function of the micro-computer controls at Thames Board. Mr. Hall had mentioned that the boiler was fired by landfill gas, together with natural gas or heavy fuel oil. Mr. Teale asked whether this meant that a mix of landfill and natural gas was used, and whether the landfill gas was always used in combination with other fuel. If that were the case, he wondered whether that was why micro-computer controls were required.

MR. D.V. JACKSON, responding to the questions in order, dealt first with the point about dioxins and furans from municipal incinerators. Although he had not been directly involved in this WSL study, he understood that the results showed emissions to be closely related to the method of operation. Incinerators operated under adequately controlled conditions could ensure that these emissions were low and acceptable, or at least in line with current UK legislative requirements. However, were legislation to become more stringent (as was possible since the Federal Republic of Germany was pressing for stricter standards via the EEC) then the situation would have to be reviewed. The problem would be not so much from the organics, but from the chlorine. If the German proposals went ahead, gas scrubbing would be required at all municipal plants.

As to WSL's plans for R & D in this area, he said that these depended upon resources and funding available. There were plans to carry out monitoring work into emissions, and work on recommending ways of overcoming problems. WSL was in the process of planning a combustion facility which would enable them to do far more work on the spot, rather than in the field. As far as RDF was concerned, WSL already had funding from the Department of Energy through ETSU, to do some fairly basic laboratory-type combustion work in order to gain a better understanding of the chemistry involved. He reminded the audience that work into combustion of coal and overcoming the associated emission problem had been in progress for decades. Combustion of RDF was a new technology and not all the problems would be discovered or solved overnight.

Refuse stank and deteriorated with age unless further processing was carried out. After the putrescible material had been separated from the waste, and the material had been shredded and pelletised, the temperature developed in the die in the pelletising machine exceeded the pasturisation temperature. If stored dry (they could not be allowed to get wet, because they would resemble dirty papier mache) the pellets would keep for months. On the other hand, it was necessary to use the shredded material (as used in cement kilns) fairly rapidly.

Referring to Mr. Heron's comments about

Easiburn, and some of the developments in East Sussex, Mr. Jackson confessed to finding himself worried by some of the uses to which the fuel was being put. Warren Spring Laboratory did not consider that refuse derived fuel pellets should be used domestically. Nevertheless, the manufacturers of Easiburn were selling it on the domestic market. Warren Spring could do nothing except express a view, direct to the manufacturers and to anyone else who asked. The combustion characteristics of the fuel, in particular the highly volatile material, made it unsuitable for use in any other than tightly controlled conditions. If the pellets were used on an open fire and volatile material was generated, an explosive mixture could form in the chimney.

Pelletising the material did reduce the bug (micro-organism) count, so it should be reasonably safe to handle but, nevertheless, WSL recommended it for use by industry, under controlled conditions only and not by the general public. As to the question of chimney height, he was glad to note that Mr. Heron had apparently solved his problem at the last moment by contacting members of the air pollution division at Warren Spring Laboratory. Regarding the wider dissemination of results of WSL research, Mr. Jackson said that this was a perennial problem. The results were published in reports, DOE issued circulars relating to work which they had funded, and results of work in progress were discussed at such bodies as the Standing Conference of Co-operating Bodies. WSL did as much as they could in this way, and yet there was always a demand for wider publication.

Turning to the question of whether the composition of RDF varied, Mr. Jackson said that, surprisingly, it was remarkably consistent. The preparation and processing helped to account for this. Basically, the fuel was paper and plastic, with varying degrees of contamination.

On the question of landfill in Northern Ireland, Mr. Jackson said that recycling was always preferable on the grounds of energy saving, resource saving etc. However, the practicality of recycling depended upn the market for reclaimed products. For example, with paper, the problem over the years had been the cyclical nature of the market. When the market was good, it was economic to separate out and sell the paper. As soon as the market diminished, the voluntary collectors of waste paper were left with tonnes on their hands and no takers. This was discouraging.

A trade and industry Select Committee had reported in 1984 with recommendations for stimulating the market for recycled paper. Amongst these was the establishment of government policies, stipulating a certain level of recycled paper, for example, for use by government departments. If government accepted this idea and some degree of stabilisation of the market ensued, it would become worthwhile to carry out a separation of materials at source for recycling. This then left the problem of disposing of the remaining waste. But, even with the cleaner and more acceptable quality of paper removed, there would still be a high component of combustible material in the waste. Then, it was a question of balancing the benefits of landfill with methane recovery, against burning the waste as shredded or pelletised fuel. At the moment insufficient was known about the respective economic merits to make a totally dispassionate judgement. In fact, there might be scope for both techniques. The highly combustible material could be taken out and burnt, and the highly putrescent material - vegetable matter - could be put to landfill with methane recovery at a later date.

Turning to the question of whether the drying of RDF, with 25% putrescible material, would produce odours, Mr. Jackson said that the processing would involve extraction of the putrescibles, which were also an undesirable source of moisture in the fuel. Thus, the odour problem during drying was minimal. There was a slight problem, but at Doncaster, for example, it had not been at unacceptable levels.

As to whether techniques for gas cleaning had improved and thereby resulted in reduced emissions, Mr. Jackson said that he was not a specialist in that area. He believed that improvements had taken place and that if new and more stringent legislation was introduced, along the lines proposed by the Federal Republic of Germany, then technological changes would have to be effected to ensure that emissions met the legislative standards. He did not have any personal knowledge of steps taken to clean the gaseous emissions in the West Midlands and Merseyside plants using RDF or firing their own driers.

MR. W.L. HALL, replying, turned first to the question about upgrading of landfill gas so that it could be distributed with natural gas on the grid. He explained that there were differences between UK and US practices. In the United States, where there were several private utility companies, upgraded landfill gas was bought in by these companies at a price marginally lower than the selling price to the consumer. But in the UK, when approaches had been made to the British Gas Corporation and, before that, to the Gas Council, mention had only been made of buying in the gas at the beach price, ie the price of landed natural gas.

Another problem was the quality of gas. If the British Gas Corporation would accept from the landfill gas producer an injection of gas at below pipeline quality, given that the dilution of the inert components would not markedly affect the heating value of the natural gas, then some upgrading of landfill gas was possible.

As to the uses of gas, he had referred to the supply of landfill gas for Thames Board. There, it was possible to meet only 1/3rd of the user's current fuel requirement when on peak stream output.

The user had a boiler with four burners; two of these were equipped to burn landfill gas and the other two to burn natural gas or heavy fuel oil. The landfill gas remained on stream for as long as possible, and as the user's demand declined, then the more expensive fuels were cut off - hence the need for micro-computer controls. These ensured that the customer got the best balance, the cheapest fuel costs, at all times. It was not necessary to mix landfill gas with natural gas, propane, butane or any other fuel. It could be burnt quite satisfactorily without any additional fuel, as had been demonstrated on brick kilns throughout Yorkshire, and (at the end of October 1985) at Cadbury Typhoo. Landfill gas would be taking over the whole of the energy requirement for that particular unit.

The need for stand-by or support fuels rarely arose; for 99% of the time, landfill gas was a reliable source of fuel, although inevitably the supplier was vulnerable to power failures and breaks in the pipeline - due to the activities of others, eg local authorities. The transmission system also had to be maintained from time to time, and the cost of duplicating a system was prohibitive. Thus, the user had to recognise that an element of vulnerability existed and arrange for a standby fuel to be available accordingly. Typically, this was one of the cheaper grades of fuel oil, which could be stored and brought on line fairly quickly.

Speakers: D.E.Shillito, D. Cope, P. Horan and Dr. R.S. Barratt

MR. O.A. DODDS (Bristol City C), opening the discussion, congratulated the speakers on the quality of both their written papers and their presentations, which had been models of clarity and precision.

Turning first to the paper by Mr. Shillito, Mr. Dodds said that he had found the discussion of the pollution control versus employment argument particularly interesting. It was a favourite topic, and the arguments on one side had been used by many people to justify the relaxation of environmental standards during a down turn in industrial output or employment, both in the long and the short term. Equally, those arguments had been rejected by experts and industrialists alike. He had found the raising of this issue by a consultant intriguing, and he wondered whether it had a greater significance than its mention during the presentation suggested. He considered that the other factors mentioned, such as market forces, exchange rates and labour costs were more significant than the pollution control costs themselves. Equally, replacement of outmoded plant, especially during quieter periods in productivity, could have particular benefits in terms of increasing the company's competitiveness. A bold decision of this sort might be preferable to hanging on to old plant and equipment in the hope that the decline in output or profitability would bottom out and upturn occur in the near future. Such an increase in industrial activity had to be positively achieved.

Mr. Dodds hoped that the reference on page 3 of Mr. Shillito's paper to the elimination of specialist environmental advisors to planning authorities was intended to encourage greater in-house expertise, and not simply the employment of consultants. Mr. Dodds said that he would deprecate any suggestion that planning and environmental health departments in local authorities should not maintain any in-house expertise in the environmental or pollution control field. He also felt that if planning departments were to rely upon the advice of consultants employed by the applicant, they should remember that the consultant owed his first allegiance to the client, ie the applicant, and not the local authority. While responsible consultants would probably be able to wear those two hats, that might not apply to all consultants.

Sticking with planning, he turned next to the outline planning stage of industrial applications. The implication that planning authorities should accept fairly general applications, rather than specific and detailed applications regarding major industrial plant had disturbed him, in spite of a shared concern that too much money and effort was sometimes spent on what could be a fruitless exercise. While he acknowledged that planning authorities were often criticised for spending too long in deciding on an application and on the environmental and other issues concerned, he felt that the suggestion that these issues should be considered at the detail rather than the outline stage was fraught with difficulty. The real problem was that once the outline planning permission had been given, the chance to deal with detailed issues at a later stage was lost unless approval of "reserved matters" was built into the outline permission.

Referring to the fifth paragraph in the section on economic roles in environmental controls, Mr. Dodds expressed some surprise that the author had advocated the use of statutory action. He agreed that in the initial stages such action might minimise the cost to the authority of prolonged discussion, monitoring and negotiation, but he considered that the negative effects would outweigh the benefits. It would increase discord and sour the good working relationship between industry and the local authority. And, taking into account the appeal process, the costs could be increased quite considerably. Mr. Dodds considered that there should be a careful balance between the occasional use of statutory powers, and the maintenance of the good working relationship between industry and the local authority. He sought Mr. Shillito's comments.

Turning next to the paper by David Cope, Mr. Dodds considered that he had exposed with great skill the impact of international influences, particularly the EEC, on the UK both now and in the future. He personally had long considered the EEC to be of vital importance to both industry and local authority staff. The Commission generated great quantities of documents, some of which appeared to be quite irrelevant to his own activities as a local authority environmental health officer. Indeed, some of the proposals seemed quite irrelevant to the development of society. For example, the notion of "vegolate" instead of "chocolate" filled him with horror. But as far as pollution control was concerned, he regretted the fact that many people seemed unaware of the nature and scope of proposals in this area emanating from the EEC, some of which could have major implications for local authorities in terms of staffing, workloads and equipment for monitoring. He asked Mr. Cope to comment on the suggestion made by Mr. Shillito that statutory action should be pursued, rather than the informal process of discussion and negotiations leading to improvements in controls. In his presentation Mr. Cope had seemed to suggest that informal action was the norm in Europe.

Turning finally to the paper by Messrs. Horan and Barratt, Mr. Dodds said that he was acutely conscious of the statutory requirements for grit and dust emissions, including the monitoring requirement. He did not favour the routine monitoring of grit and dust or any other emissions. He favoured the employment of monitoring from time to time on the "stick and carrot" approach. Such monitoring was a stick to hold in reserve for use when the situation warranted it. In Bristol, his department preferred to use the informal rather than the statutory enforcement approach. The department had a BCURA probe and used it when necessary. On a lighter note, adding to the list of disadvantages of the probe, Mr. Dodds said that it had a tendency to burn people′s fingers if they were not very careful in its use!

He had considerable reservations about the emission monitoring proposals emanating from the EEC, and indeed some of the implications of the current debate on freedom of information. He supported freedom of information as a concept, but as far as environmental data was concerned, he wondered to what extent the public were interested, informed, and would benefit from an increased body of data were it to be made available to them. Every year in Bristol an Annual Air Quality Report was produced, containing information from the Bristol City Council, the Industrial Air Pollution Inspectorate, from industry and from other local authorities. It was a detailed compilation of a lot of data, which took a good deal of time to prepare. It was freely available to the public, but was never used. The public did not seem interested, and the media never took any notice of it. This experience led him to wonder whether the pursuit of freedom of information and the increased monitoring effort would actually have positive results.

DR.F.E. SHEPHARD (British Gas Corporation) said that Mr. Cope had mentioned in passing that he would not discuss hydrocarbons emissions, but that most of these emissions came from natural gas. Dr. Shephard wished to put the record straight. If Mr. Cope had got his information from the DOE Digest of Environmental Protection Statistics, then he would advise him that the published data was inaccurate and misleading. The Digest, Number 7 (1984), gave a figure for hydrocarbons from gas leakage of 2.25 million tonnes. A footnote explained that this gas leakage was an estimate of losses during transmission along the distribution system. Dr. Shephard said that this figure was out of all proportion to reality and British Gas had so informed DOE and Warren Spring Laboratory and a correction would be published in the Number 8 edition of the Digest.

Having cleared up that point of fact, Dr. Shephard asked Mr. Cope what message exactly he was trying to give local authorities about the large combustion plant Directive. He wondered whether Mr. Cope was seriously suggesting that local authorities should wholeheartedly support the application of that Directive, right down to installations of 1 and 2 MW. In his view that could be a tremendous waste of resources on a cost-benefit basis.

MR. R.W.C. WHEATLEY (National Coal Board) said that Mr. Cope had referred to coal preparation as a means of reducing sulphur in the coal. He said that the NCB had examined this point very carefully over the past two years. They had discovered that if all the coals supplied to power stations were washed, the sulphur content would be reduced by 6%. This was less than the reduction that would be achieved by a single retrofit at a large power station. However, the comparative costs were out of all proportion, with the cost of the coal preparation being three times as great as the FGD installation.

On the other hand, the NCB entirely supported the comments made by Mr. Cope about the implications for fluidised bed combustion of the very stringent emission limits which were proposed. However, he pointed out that the restrictions that these limits imposed on the conventional coal fired plant were sufficient to have very serious implications for employment in the UK coal industry. The limits proposed for the smallest of the plant covered by the draft Directive meant that the average sulphur content of the coal supplied would have to be lower than the vast majority of UK coals. Thus, coal would probably have to be imported from outside the EEC - particularly from South Africa and Australia - for these plants, even though their contribution to total UK emissions was minimal.

MR. J. EVANS (Rhymney Valley DC) said that Mr. Shillito had mentioned the best practicable means approach. While there was no doubt that BPM had served the UK well for many years, he asked Mr. Shillito whether another close look should be taken at BPM and the "best practicable environmental option" approach, to ensure that industry could not wriggle out of enforcement by relocating and playing one local authority off against another.

MR. S. CARDEN (Barnsley MBC) asked Mr. Cope whether the low interest shown in pressurised fluidised bed combustion in the US, in terms of technology available for the clean use of coal, should be viewed by those in the UK with some disappointment. He asked Mr. Cope whether he would generally agree with the statement that the technology for the clean use of coal existed for both large and medium-sized installations.

MR. G. STOTT (HMIPI, Scottish Office) said that he had been puzzled to read the statement in Mr. Shillito's paper, that it would be necessary to move from what was viable in terms of environmental control, to best practicable means. He asked for clarification of the point, since best practicable means took into account the best available technology as well as the economics. If the suggestion was that the best available technology was not usually employed, then that suggestion was clearly wrong.

Commenting on the glossy environmental impact assessment brochures produced by some consultants, Mr. Stott made a plea that companies should consider public relations when they produced these brochures. He had read some which had referred to the number of deaths which would occur in a particular neighbourhood as a result of gaseous emissions, without attempting to put the figure into context by quoting comparable risks on smoking etc.

He had intended to ask Mr. Cope to expand on the value of the low sulphur Scottish coals, but that point had already arisen. It would be useful and desirable to have a quantification of the cost of importing low sulphur coals and mining the Scottish low sulphur coals, compared with the cost of flue gas desulphurisation.

Turning to the paper by Mr. Horan and Dr. Barratt, Mr. Stott said that he had enjoyed the presentation very much. The Inspectorate north of the Border - and he believed that this was true of the Inspectorate south of the Border as well - had begun to move from the relatively simple measurement of particulates, to the measurement of hydrocarbons and other substances, some of which were very exotic. When the Inspectorate approached various experts in measurement, and asked them whether they would be capable of measuring exotic component "x", they were usually met by cries of anguish. He wondered whether NIFES would care to develop measurement methods for substances other than particulates.

CLLR. J.J. BLEWITT (South Oxfordshire DC) asked whether the speakers considered that the Government White Paper referred to by Mr. Shillito, "Lifting the Burden", would undermine the efforts made by the National Society for Clean Air and others over many years to secure environmental protection at the outset, in the planning stage. He considered that if the principles in the White Paper, of cost effectiveness and promotion of jobs by lifting the burden of planning and other controls, were accepted, the effectiveness of air and noise controls could be seriously eroded. He believed that it would be hard to recapture the effectiveness of these controls once the impetus was lost.

As an example, he quoted the case of stubble burning. It had taken years to raise the profile of this issue to the point where the incidents were recorded, new and more stringent model bye-laws had been introduced and farmers had generally accepted the need to change their ways. Cllr. Blewitt supported an outright ban on straw and stubble burning, but he felt that such moves looked increasingly unlikely in view of the sentiments behind "Lifting the Burden". It was important that people should keep in mind what quality of life they had striven to achieve and would like to keep. He considered that the environmental quality of life, at any rate, was in jeopardy as a result of the strictures in the White Paper.

MR. D. SHILLITO, replying to questions, said that he had used the term "best practicable means" as the authority, rather than the polluter, would prefer to understand it. Local authorities had to use their limited resources as wisely as possible. It was obviously desirable to co-operate with industry provided that it would produce the desired results. However, where industry had adopted a fixed position or where promised actions did not materialise, co-operation was not "practicable". Prosecution, although less desirable, became the only practicable means.

The point he had made in the paper was that where industry was placed in a position of economic peril, it would become devious. Even though the Public Health and Planning legislation only armed the authority with rubber teeth, a sudden nip from that source could produce bruising which might have benefits in the long run. For a start, it could help to engender respect for the local authority within the industry. One of the troubles at present was that some areas of industry held local authorities in scant regard and were using their economic difficulties as an excuse to renege on their duty with regard to environmental pollution controls.

As to expertise within planning departments, he agreed with Mr. Dodds that planning departments should have their own environmental control specialists. However, these could not be expected to cover the whole range of industrial processes and be expert in all the areas that the planning applications might cover. The point of using the environmental impact statement approach was for the developer to simplify his application to a level at which assessment by the planning departments' own specialists would become feasible. Then, if need be, expert consultants could be brought in.

The use of a planning permission as an initial screening only worked in certain process industries; with the mining industry, for example, a full assessment would be needed before even outline planning permission could be given.

Turning to the point raised by Mr. Stott about the difference between what was desirable and what was practicable, Mr. Shillito said that again, the nub of the question was finance. If industry could afford to invest in the best available technology, thus making it "practicable" within the meaning of the term applied by the air pollution control Inspectorate, industry also had to afford the correct maintenance of the plant and its proper operation during its lifetime. For example, the employment of electrostatic precipitators as Best Practicable Means was incomplete unless these were maintained and operated properly. Because no control authority could afford to maintain inspectors on the spot in the plant every day of the year to make sure that the control equipment was working properly, there had to be other ways of ensuring that that was the case, and that breakdowns were reported effectively and that any resulting emissions were properly logged.

As far as checks on plants were concerned, monitoring was only worth carrying out after the integrity of the plant and pollution control equipment had been verified. Otherwise, the data would only be worth collecting for the purpose of prosecution.

As to glossy environmental impact statement brochures, Mr. Shillito considered that the risks, particularly from major hazardous installations, had to be put into the statement and that this was usually done in a balanced way with a perspective on other risks in the area. There were certainly ample guidelines in the growing body of publications dealing with environmental impact assessment.

Turning to "Lifting the Burden" and the questions put by Councillor Blewitt, Mr. Shillito said that environmental achievement would only be put in jeopardy if the local authority lacked the money to maintain the level of environmental controls.

MR. D. COPE replied first to the point about informal rather than formal action put by Mr. Dodds and whether the use of informal action was more widespread on the continent of Europe than in the UK. Mr. Cope said that his impression was that local authorities in continental European countries generally had wider powers and greater discretion in the exercise of those powers than their counterparts in the UK. This was partly because the utilities tended to be private and locally-based, so that the local authorities had representatives on the control boards of the plants and were able to establish the standards they wanted from within rather than from outside. Generally speaking, he thought it preferable that flexibility in control policies be maintained, so that local authorities could take their own action at their own discretion. Clearly, that implied that in some circumstances local authorities would enforce regulations that were less stringent than national standards. A recent case of that nature in a European country came to mind, in which the national authority had rapidly stepped in and used national statutes to prevent the local authority from going ahead with a more relaxed standard.

Saying that he had obtained his figure on hydrocarbon emissions from the DOE Digest, Mr. Cope thanked Dr. Shephard for his correction. As to whether the intentions of the large combustion plant Directive should be enforced all the way down to the 1 or 2 MW level, Mr. Cope made it clear that he did not think it should be enforced on the same terms. The German and Austrian proposals certainly envisaged a different application of standards according to the size of the plants. At the same time, however, the German regulations also imposed emission controls on hydrocarbons emissions and trace elements for smaller plant (less than 50 MWt).

Whether the application by local authorities using informal means, of possibly tighter than national standards was more effective than the statutory prosecution approach, was a difficult question to answer and rather similar to comparing apples with pears. He was sympathetic to the suggestion if it reflected the desire of the electorate in the local authority. Elsewhere he had suggested that the money spent on cleaning up the last 10% of emissions from small sources might in some circumstances be better spent on other forms of environmental improvement such as clearing up the landscape dereliction of the past. The controlling factor would be the express choice of the electorate in the local area.

As to the sulphur content of coal, he considered that he could not elaborate on Mr. Wheatley's comments except to say that there was already some concern about the environmental impact of the residue from coal preparation activities in coal mining areas. More intense coal preparation would inevitably exacerbate the disposal problem to a certain extent. Again, it was a question of apples and pears but it was generally easier to dispose of fly ash than to dispose of the residues of coal preparation;in particular, the very fine residues. That was another reason why coal preparation should not, in the British context, be looked upon as contributing a great deal to sulphur pollution abatement. He agreed with Mr. Wheatley that the Scottish coals were roughly equivalent to the compliance level at the lower end of the Directive. While he could not comment on the many questions, including the economics, involved in expanding the mining of Scottish coals, he agreed that it was a point worth bearing in mind when considering the coal from that area.

As to whether the UK should be disappointed about the comparative lack of interest shown in the United States in pressurised fluidised bed combustion, Mr. Cope said that the IEA had promoted the first stage of the PFBC plant at Grimethorpe. He believed that PFBC had generally been regarded as a window of technology; in the longer term, the prospects for combined cycle gasification would be greater, particularly in terms of ease of clean up and efficiency. PFBC would probably always be disadvantaged against gasification because of the problems of waste disposal. But at present, it was necessary to advance all technologies. Thus, he considered it essential that the proposed full-scale plant near Stockholm in Sweden, based not on the NCB/CEGB Grimethorpe project technology but that of the ASEA/Laval test facility at Malmo, in Sweden, should go ahead so that the actual commercial operation of PFBC could be demonstrated.

Note: this has subsequently been rejected by the Swedish Environmental Franchise Board on the grounds that PFBC is an untried technology and because coal stocking was not considered desirable in the area of the proposed site.

DR. R.S. BARRATT, responding to Mr. Dodds, said that he would not basically disagree. He had indicated that the first step was to assess the plant visually and check that the control equipment was working properly. Only then should measurements be carried out, as a last resort. As to the disadvantages of the current measuring equipment, time had precluded discussion of all those shortcomings. A few more had been mentioned in the written paper, but he certainly agreed with Mr. Dodds about burnt fingers.

As to the need for more monitoring, he had pointed out that most calls upon NIFES' services were in relation to the commissioning of new plant rather than checking upon existing plant. The plea that he had made in the paper was for a method that would enable measurements to be carried out more uniformly and more easily across the community, given that new emission standards were introduced which would of necessity require further monitoring.

He had been rather amused by Mr. Stott's reference to moving from "simple" means of measuring particulates to the measurement of other more exotic emission components. By "simple", he assumed the questioner had meant a method that did not require calibration since it was a direct measurement technique. However, the measurement of volatiles and gases did not entail the use of isokinetic sampling that was required with particulates. NIFES were certainly called upon to measure substances other than particulates, but whether or not they would develop a practicable standard method for other substances would depend upon the market for the method. Since NIFES was a commercial organisation, it had to be sure of an increasing demand in the future for the development before it could spend time and money on new measurement methods.

MR. P. HORAN wished to add a comment about the continuous monitoring of particulates. The methods available were, he said, expensive and did not meet the British Standard requirements for "routine" monitoring. He made a plea to the commercial manufacturers for a greater effort towards the development of cheaper continuous emission monitors for particulates.

DR. R. WOODROUGH (Erwin Sick Optic Electronic Limited) asked whether there was a major typographical error in the penultimate paragraph of the paper by Mr. Horan and Dr. Barratt, or whether the authors had failed to consult with the CEGB, the Industrial Air Pollution Inspectorate and the Cement Industry before drafting the paragraph which referred to continuous particulate monitoring.

DR. BARRATT said, without looking back at his paper, that he was certainly aware of the considerable amount of work and discussion that had taken place jointly between the Cement Industry and the IAPI on continuous measurement methods. However, according to his latest information, despite all the research effort, there were still difficulties in the way of effective continuous measurement of particulates.

MR. HORAN said that what was written in that paragraph was essentially true. The current regulations laid down that monitoring should be carried out in accordance with BS 3405. The British Standard did not allow any continuous monitoring method to be used and until the regulations were rescinded, only the methods prescribed in BS 3405 could be used. The Standard specified three pieces of equipment: the NCB, the CEGB and the BCURA equipment. It also stated that other methods could be used, but there was no system within the British Standard which would allow other methods to be approved. Thus, if another method, a continuous method, were developed, it would have to be approved to the British Standard - yet the mechanism for doing that did not exist.

Speakers: Dr. A.D. Wrixon and D.S. Durston

DR. M.J.R. SCHWAR (Greater London Council, Scientific Services Branch), opening the discussion, congratulated the organisers for twinning the two papers, on indoor air pollution from radon gas and on asbestos. The two subjects had many parallels in terms of levels of risk and lessons that could be learnt from comparing the way in which each problem area had been tackled. He also congratulated both the speakers for the interest and considerable attention to detail apparent in their presentations and in the way that they tackled the respective problems.

Both speakers had referred to the risks associated with, in the one case, natural levels of radon in buildings, and in the other case, unnatural levels of asbestos in buildings. As he had understood the figures, he believed that the lifetime risk of dying of cancer as a result of exposure to radon was in the order of one in 1,000. As to asbestos, the report by Doll and Peto, together with the epidemiological analysis of other workers (and these related to exposures in the asbestos industry) suggested that the level of risk was very similar : extrapolating those figures down to concentrations of the order of 0.01 fibres per millilitre, for several hours a week (and such exposures could arise in buildings on rare occasions), then the level of risk was in the order of one in 1,000 or so.

It was also interesting to note the level of public perception of the two problems. In the case of radon, he considered that the work of the NRPB was going steadily ahead in a very methodical way, leading to identification of the areas where the risk was highest and finally devising a strategy to reduce exposure in those areas. However, in the case of asbestos there were strong pressures to act straightaway without assessing the problem properly in all areas. Dr. Schwar was concerned by this, since it was his strong impression, and that, he deduced, of Mr. Durston, that problems could be created in many instances by the removal of asbestos.

In making these remarks, he was not referring to the severe cases where the asbestos was in such a state as to totally warrant attention and removal. There was no doubt in anyone's mind that where such situations existed, remedial measures needed to be taken as a matter of urgency. His concern focused on the situations where asbestos concentrations were not above 0.01 f/ml and yet a decision had been taken to remove the asbestos. The mere process of removal would produce concentrations which would be much higher than 0.01 f/ml. Indeed, he was aware of exposure situations comparable with occupational exposures, which had occurred after asbestos had been removed and (inadequate) cleaning had taken place. Superficially, and to the naked eye, the area would appear clean. However, when air sampling was carried out competently, concentrations of the order of 1.0 f/ml would be found. He regarded that situation as extremely worrying.

The real question was whether asbestos should be removed if air sampling showed concentrations to be less than 0.01 f/ml. Dr. Schwar expressed interest in any data David Durston had of concentrations before asbestos was removed, both in the extremely poor condition asbestos cases he had shown and in other, better cases. In measurements carried out by the GLC, with analysis by scanning electron microscopy, buildings in normal use had never proved to have concentrations higher than 0.005 f/ml. Thus, asbestos removal and clearance to 0.01 f/ml would expose people working in those ordinary situations to a rather greater risk than if the material was left in place. It was a very fine judgement that had to be made in deciding whether the net risk would be increased or decreased by removal.

Dr. Schwar asked Mr. Durston whether, in his experience, agencies could be relied upon to carry out adequate clearance tests after asbestos removal. In Dr. Schwar's own experience, the checks carried out after removal often left something to be desired - sometimes the agencies relied upon untrained staff. He considered quality control to be absolutely essential. In this respect, he was not referring to the RICE Scheme, but to checks on the quality of the actual sampling method and the care taken during sampling. In his experience, it was possible to go into a room and see visible signs of contamination on the ground, and yet concentrations had been reported at below 0.01 f/ml. As people walked around in those circumstances, causing a degree of dust disturbance, concentrations of asbestos in air could exceed the occupational exposure limit. He found that situation, of incompetent removal of asbestos and incompetent final testing, extremely worrying.

He asked Dr. Wrixon whether the approach taken in dealing with radon might be usefully applied to the problem of asbestos. He asked whether Dr. Wrixon considered that more sampling of levels indoors, using electron microscopy for analysis, should be carried out to get a better picture of levels of asbestos in buildings. His work to date had not found high levels - it was like looking for a needle in a haystack - but he considered that perhaps the effort should be concentrated.

MR. D.S. DURSTON, replying, said that he had stuck to the reference figure of 0.01 f/ml since at levels 1/10th or 1/100th of that, it was very difficult to repeat tests and view the results with any confidence. Looking at fibres under an optical microscope, one could identify the presence of material of a size which, if asbestos, could be dangerous to health, but you could not know that the material was asbestos. There were other fibres in the atmosphere in addition to asbestos, of the same diameter and length.

In terms of concentrations in the order of 0.00x f/ml or 0.000x f/ml, he was unaware of any risk assessment which would assign a value of the "deaths per thousand" order. There were figures supported by a lot of research work which related to concentrations at one decimal point, and at 0.01 f/ml the risk was thought to be a death rate of one in five thousand - but that was for continuous exposures, not occasional exposures. The limits derived years ago, of 2 f/ml for white and brown asbestos, and 0.2 f/ml for blue asbestos, were for continuous, occupational exposure, ie for a complete working life of 40 hours per week for x number of years. On the basis of those levels it was reckoned that one in one hundred workers would contract some form of asbestos-related disease. Since the 1960s, however, the sensitivity of measurement methods had improved by a factor of three or four. The more sensitive measurements revealed that the old standard was really 10 f/ml rather than 2 f/ml, which resulted in 1% mortality. Thus, the current exposure limits had three or four levels of safety built into them, over and above what was originally intended.

As to deciding upon which laboratory to use for measurement/analysis, Mr. Durston said that the first rule was always to make a thorough visual survey of the area before embarking upon fibre counts. If there was any evidence whatsoever of dust in the area, then the cleaning had obviously not been done properly and the firm undertaking the cleaning should be told to do the work again. Fingers should come away from all surfaces absolutely clean and if they did not, if there was any evidence of dust on the fingertips, then there was no point in monitoring. As an illustration, Mr. Durston said that in the large Conference Hall in which delegates were sitting, the limit of 0.01 f/ml would be reached by fibres that would amount to the mass of a 1 ft long hair from a human head. Thus, it was absolutely vital that the analyst or laboratory technician carried out visual and fingertip inspection work first. Air counting was the final task.

DR. A.D. WRIXON wished to clarify his use of the word "risk" in his paper and presentation. He explained that a risk of 1 meant absolute certainty, a risk of 10 -1 meant a risk of 1 in 10 and a risk of 10 -2 meant a risk of 1 in 100. The risk associated with exposure to radon decay products was a risk of death from lung cancer. The lifetime risk of death from lung cancer calculated by the NRPB for the average exposure to radon decay products was about 4 x 10 -4, or 1 in 2500. For the country as a whole, the NRPB calculated that between 300 and 400 lung cancer cases per year could be due to radon decay products in dwellings.

He pointed out that in the short term, there was little that could be done to reduce this incidence of death due to lung cancer. The main concern at the present time must be to prevent individuals from being subjected to too high a level of risk. Continuous exposure at the action level suggested by staff of the NRPB and supported by the Royal Commission on Environmental Pollution was equivalent to a lifetime risk of death from lung cancer of about 1 in 50. The recommendation was that effort should be concentrated on identifying those dwellings in which exposures above the action level occurred, so that remedies could be implemented.

CLLR. MISS C. McNICHOLAS (Mansfield District Council) questioned Dr. Wrixon on the sampling method used in the survey of radon in houses. Dr. Wrixon had shown a slide of the equipment and she wondered what instruction had been given to the householders who had to use it, and whether NRPB had been satisfied with the quality of the sampling done by these lay people. She asked whether the NRPB team had made personal visits to check that the equipment was being used correctly, or whether all the instructions etc were communicated by post.

Secondly, she asked whether the levels of radon in houses surveyed were compared with readings taken outside the house, in the immediate local environment, ie in the garden or the street nearby. She was particularly interested in the experimental removal equipment used to transfer the radon gas from under the floor to the outside of the house. She wanted to know whether this could cause problems in the immediate vicinity of the house and whether there were any other methods of extracting radon gas.

DR. WRIXON said that he had brought with him a package containing the sampling apparatus. He invited Cllr. Miss McNicholas to examine it at the end of the session. The package also contained the accompanying instructions. All the householder had been asked to do was to place the monitors in a convenient position in the home. One or two small conditions were attached to that basic instruction, but nothing too onerous. Once the monitoring period was up, the NRPB wrote to the householder, enclosing a box for the return of the monitors for processing at the NRPB.

No follow-up surveys had been carried out but, before the national survey was started, a pilot survey had been conducted in about 140 houses of NRPB staff, for a period of about one year. Approximately 20 of those houses had been visited following the survey and further measurements made. The results showed that the monitors could provide satisfactory results.

Normally, radon released from the ground outdoors was rapidly dispersed and concentrations in air were low. Even during periods of inversion conditions when dispersion was substantially reduced and radon concentrations rose, they were still only a fraction of the levels observed indoors. Nevertheless, so that comparisons could be made with indoor levels, measurements of outdoor concentrations had been made by the NRPB throughout the country.

The radon concentrations in the air vented from devices that extracted the gas from under the floor would be high. However, as the gas was rapidly dispersed outdoors, it was most unlikely that use of such devices would cause significant exposures of others in the vicinity. Nevertheless, some precautions would seem sensible to avoid venting the gas into neighbouring houses.

There were essentially two ways of limiting exposure to radon decay products. One was by preventing the gas from entering the dwelling. The underfloor extraction system was one method of doing this. Sealants and membranes over the floor might also have a role. The other way was by removing the radon decay products from the dwelling itself. Increased ventilation was one method of doing this. Another method was by the use of electrostatic precipitators. These devices were used for removing particulate material from the air. They were effective against cigarette smoke and also could be used for reducing the radon decay product concentration. There was, however, a penalty to be paid. The characteristics of the aerosol were changed, causing the dose per unit intake of the decay products to rise significantly. Thus the NRPB did not consider this type of device to provide a particularly satisfactory solution.

MR. I.W. BARKER (Leicester Polytechnic) asked Mr. Durston whether it was illegal to install asbestos products in new houses. As far as he was aware, the new Building Regulations had not included a prohibition on the use of asbestos. In any event, those Building Regulations would not apply to existing buildings. Recently, he had seen a new installation of a free-standing heating appliance that was sealed with asbestos rope. People were so obsessed with removing asbestos on a large scale that they seemed quite to ignore the fact that asbestos-containing components could be installed quite overtly and legitimately. While he was aware that the bottom had fallen out of the asbestos products market in recent years, he believed that many builders' yards would contain redundant asbestos board and other material, eg rainwater goods. He wondered if they would stay in the builders' yards, steadily deteriorating with time or whether, when the fuss about asbestos died down (if it ever did) they would be brought out of store and put into more buildings.

Also, as far as he was aware, it was not yet illegal to import asbestos-containing materials into the country. He entirely agreed with Mr. Durston's point that people were far too obsessed with stripping asbestos out of buildings. He thought this was particularly absurd when nothing was being done to stop people putting asbestos-containing material into buildings. The second point was that, having removed this material which, although potentially very dangerous had been very useful and had probably saved many thousands of lives over the years, substitutes had to be found, preferably materials which had many of the benefits, such as fire retardation, that asbestos had. He suspected that if a material with the same wide range of applications as asbestos was eventually found, then it could well be fibrous material itself. He wondered whether the risks of substitute material had been properly evaluated, and whether it was possible that in 20 years' time or so there might be another public furore about the risks of materials that had been chosen in the 1980s as alternatives to asbestos.

MR. DURSTON, replying, said that as far as he was aware there was no law which prohibited the use of asbestos cement products in buildings. Indeed, the current Code of Practice on work with asbestos materials etc specifically excluded asbestos cement, and HSE were considering to what extent this material should be included in a future Code. Asbestos cement had been generally demonstrated not to be dangerous. It was used extensively in pipework, both below and above ground and was commonly used for rainwater goods and corrugated sheeting. The bonding within the cement was such that the amount of fibre given off was relatively innocuous, except when the sheets were brand new and rubbed together. Tens of thousands, if not millions, of buildings in the UK contained asbestos cement sheet. Mr. Durston said that if there had been a risk from that source, the results would have been obvious in terms of an epidemic of asbestos-related diseases. Whereas with radon it could not be determined for certain that it was responsible for death, in a post mortem, asbestos could be identified as the culprit in the lung. Thus, if asbestos in buildings was causing trouble, the evidence would exist.

Replying to the point about the heating installation with asbestos rope, Mr. Durston expressed surprise that Mr. Barker had been able to identify asbestos rope so positively. If indeed that identification had been correct, he was surprised that it should have been used when there were alternatives available. However, most of the alternatives were more expensive, which was a problem. As to imports, it was now illegal to import brown or blue asbestos, ie crocidolite or amosite. It was also illegal to import any material containing crocidolite or amosite. It was NOT illegal to import or to manufacture materials containing chrysotile - white asbestos. Chrysotile was used to make asbestos cement products. There was a significant difference between the white, and the brown and the blue forms. The white asbestos tended to be far less dusty. The fibres were curly in shape, whereas the brown and blue were straight fibres and tended to dust off into the atmosphere far more readily. For that reason, and because manufacture using chrysotile was continuing, the occupational limits had been set at a slightly higher (more relaxed) level than those applying to amosite and crocidolite.

With regard to substitutes, fibreglass was the obvious choice where temperatures were not very high. There had been a certain amount of concern about the similarity between asbestos and fibreglass. Certainly, in fibreglass some of the fibres were as small as the harmful asbestos fibres; but in terms of the form of the fibre, there was a significant difference. Examination of an asbestos fibre under a microscope would reveal it to be similar in a sense to a matchstick, ie it could be broken down into fibrils lengthways, far smaller in diameter than the original fibre. By contrast, examination of the fibreglass under the microscope would reveal it to be a solid piece of glass. To put the medical effects very crudely, the fibreglass would produce two scars, one at each end. But as the asbestos gradually deteriorated in the lung, it would produce more and more scars as one end broke down into maybe as many as 50 ends in the lung. It was the multiplicity of wounds that could be produced in this way that was a cause of the asbestos-related diseases in the lung.

MR. G.R. CHARNLEY (Southampton City C) said that the environmental health department in his council were well up the learning curve in terms of monitoring asbestos removal. Indeed, the department was graded as a Category I RICE Laboratory. He recounted a case of undue stress being caused in one instance to Southampton City Council staff when blue asbestos had been removed from the offices. They had gone into work one morning and found dust in the offices, well outside the removal area but alarming for all that. In fact, it was not asbestos dust at all but the cleaners had not bothered to clean the offices thoroughly before the asbestos removal commenced.

He shared Mr. Durston's strong reservations about the licensing of asbestos removal contractors. In practice, it left a lot to be desired. Another insight from his experience related to negative pressure. Even where tents were kept under negative pressure, ballooning effects could occur because of the different air pressures in and around the building.

MR. DURSTON, in reply, first mentioned ARCA - the Asbestos Removal Contractors' Association - which had been set up some five years before in an attempt to control the cowboy element in asbestos stripping. Initially, there had been a feeling that if the reputable firms, which were forced to charge high prices because they used expensive techniques, banded together, they might have more chance against the cowboys who were undercutting them with cheap and ineffective techniques. However, ARCA had grown beyond that and was now a well respected organisation. Mr. Durston said that he was himself an Associate Member and served on the Association's Technical Sub-Committee along with a senior member of the HSE Executive from Bootle.

Mr. Durston explained that he had raised the subject of ARCA because it had attempted to vet removal contractors - he himself was one of the vetting team. He was an independent consultant, with no commercial axe to grind. Potential new members of the Association paid for the vetting procedure, which involved one of the ARCA team first visiting the company to see whether its members knew what the job was all about. They then visited the stores and workshop facilities and finally insisted on visiting a site where the company was actually carrying out asbestos removal. Once this was done, Mr. Durston or his colleagues submitted a report to the Council of ARCA. If, in spite of the report, members of the Council knew that the firm were rogues, then they would be refused admittance to the Association.

In the early days, ARCA had not possessed independent scrutineers. In effect, in the beginning, contractors were going around trying to vet their competition, a pretty difficult situation at the best of times. Thus, ARCA did contain some members which were nowhere near up to the standard which ARCA wished to maintain. The remedy was in the hands of the customer and the enforcing local authorities. If they employed or they came across an ARCA contractor who failed to meet the required standard, either through lack of knowledge or through sheer carelessness, they should contact the secretariat of ARCA at 45 Sheen Lane, London SW14 8AB, and tell them of the difficulty, with confirmation of the case in writing. The facts had to be accurate since a contractor's livelihood could depend upon it but the important thing was for ARCA to be informed of any failing in one of its members.

Turning to the question of negative pressure machines, Mr. Durston said there were now some 50 companies in the UK manufacturing these products which extracted air from the enclosure, filtered it and discharged it to the outside. ARCA had produced their own Guidelines for such equipment. As one of the team that helped to produce that Guideline, Mr. Durston explained that one of the failings or missing links in many of the machines was that the fan was insufficiently powerful to beat the outside wind. The ARCA guidelines stipulated that 3 inches of water gauge - 750 pa - was the minimum fan head that should be available in order to cope with wind when discharging outside. Some of the pieces of equipment (they were hardly worthy of the name) were put on the market by metal bashers who assembled a fan and a filter from various sources and thus produced a so-called negative pressure unit. The result was a disaster. Thus, HSE had insisted that wherever it was reasonably practicable, the discharge should go to the open air, so that if there were any fibres in that supposedly clean air they would not be returned to build up in the internal atmosphere. But the problem with blowing air outside was that there could be a back pressure with wind blowing against the building. Thus, the ARCA Guideline specified a non-return valve which ensured that when the wind blew onto the extract fan discharge there would be no pressurisation in the enclosure - the wind could not reverse the flow. The Guideline also contained details such as how the filter should be sealed etc but these were too numerous to go into at that time.

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52nd ANNUAL CONFERENCE
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SCARBOROUGH

PRESIDENTIAL ADDRESS

By

Cllr Len Poole, BEM, JP

NATIONAL SOCIETY FOR CLEAN AIR
136 NORTH STREET
BRIGHTON BN1 1RG
ENGLAND

THE PRESIDENTIAL ADDRESS

by

CLLR. LEN POOLE, BEM, JP

President of the National Society for Clean Air

Today, I am the proudest man in the land, the Society having conferred upon me its highest accolade by electing me as your President. No doubt the Society would cite many reasons for bestowing this office upon me; for my part I am clear that I have done no more than my job as an elected representative of the people of Middlesbrough demands, and because of this I feel that the Society is also recognising the splendid achievements of the local authorities over the years in improving the environment.

Looking at the long list of my distinguished predecessors, I am flattered and humbled by my election to their company - and tickled pink to think that the title of "Councillor" now appears upon it. But whatever our backgrounds, the one thing that I have in common with each of my predecessors is a fervent commitment to clean air and the promotion of a cleaner, healthier, quieter environment.

But times change and priorities change and I have, therefore, been reading the history of the Society to see what lessons it may have for me in my new role. In a few minutes I can, of course, do no more than highlight some of the main events.

Despite changes in name and a merger, the Society traces its descent directly from the Coal Smoke Abatement Society - that was formed in London in January 1899 after a series of preliminary meetings the previous year. The Society bore that explicit name for the next 30 years.

Its first objective was to enforce the law. In 1891 a Public Health (London) Act had been passed which included smoke nuisance provisions similar to those introduced for the rest of the country in the Public Health Act 1975. However, the Vestries - the forerunners of the Borough Councils - neglected to use the powers provided in the Act to the extent that our founding members were convinced that they must form a Society to obtain evidence with which to institute prosecutions and prod the local authorities into bringing them. The resolution passed by the first meeting read:

> "That a Society be formed, and a Committee apppointed, to consider and report how best Vestries and other municipal bodies can be aided by public support to enforce the clauses in the Public Health Acts which relate to smoke consumption."

In the next 10-15 years, the young Society made striking progress. It acquired a part-time paid Secretary and other, voluntary, staff to implement the recommendations of the Committee. By 1902 it had completed its first important investigation - the testing of domestic grates. The results were published in The Lancet. However, the routine work of the Society was to press for the law to be administered - and, as funds permitted, it employed its own inspector, a Mr.William Petty. In 1903 he reported 2000 observations leading to 1278 complaints being forwarded to the local authority.

By that time a number of authorities were employing their own inspectors but, as you might expect, the Society was not popular with those less enlightened. One authority in East London received 572 complaints without a single case being brought before the court - despite the fact that in two cases the nuisance was so scandalous that an adjoining Borough had issued summonses on the report of its own officers and had obtained convictions!

In 1905 the Society was able to hold, jointly with the Royal Sanitary Institute, its first Conference and Exhibition. 1906 was particularly interesting in that the Society extended its remit beyond smoke abatement to include indoor pollution - with a programme to test gas fires and gas stoves for carbon monoxide and other emissions.

In 1907 the Society inaugurated a movement which it has fostered and encouraged ever since - the training of boiler operatives and stokers. And so its work continued. In an interesting and far reaching development in 1910, the Society initiated a scheme, in conjunction with the commissioners of The Lancet Laboratory, to monitor particulate fallout in the Metropolitan area. A gauge was constructed for catching the deposit which was in all essentials exactly the same as that used today. Three sites were chosen and the deposits were analysed for insoluble matter, sulphates, chlorides and lime. From this small beginning the observations were continued and expanded and, in 1912, handed over to the Meteorological Office which continued to supervise and collate the records until 1926 when the work was taken by the newly established Standing Conference of Co-operating Bodies and the Department of Science and Industrial Research became responsible for the Government side.

In less than 30 years the Coal Smoke Abatement Society had established a solid reputation for innovative thinking, for balanced argument, for progressing research and for public education.

While the Coal Smoke Abatement Society was concentrating its efforts in London, other cities were forming their own associations and in 1909 those in Leeds, Glasgow, Manchester and Sheffield met in Conference and formed the Smoke Abatement League of Great Britain with its headquarters in Manchester.

Whilst the Society and the League were well disposed towards each other and progressed much of their work in concert, the first World War halted progress and it was some years after before the two bodies were to move forwards again. In the early 20s they concentrated their efforts on supplying evidence to the Government which led directly to the passing of the Public Health (Smoke Abatement) Act of 1926.

It is interesting to note the differences in approach between the London Society and the Manchester-based League. The Society had depended entirely on individual subscriptions and had turned its face resolutely against contributions from industry and commerce. The League, on the other hand, made a drive for the support of the local authorities and was prepared to receive help from any "vested interests", while making claim that such support would not interfere in any way with its independence! In 1928 the Society and the League amalgamated to form the National Smoke Abatement Society with head-quarters in Manchester. Dr. des Voeux was elected as the first President and Arnold Marsh was engaged as the Society's first full time paid General Secretary and Editor. Annual Conference started - the first being held at Buxton in 1929 and the second at Leicester in 1930. That the latter even attracted a Civic Reception shows just how far the Society's relations with the local authorities had improved!

Nevertheless, the 1930s were as difficult for the Society as they were for the nation, struggling against economic recession, a surplus of coal and widespread unemployment in the mines. However, membership and influence grew and new ideas were advanced and discussed. One which deserves special mention was the brilliant concept of the smokeless zone which was put forward by Charles Gandy - a Manchester barrister who was also Chairman of Council. As you will know, this idea was developed into the smoke control area which became an integral part of the 1956 Clean Air Act. Another idea put forward by the Society was that of prior approval to ensure that all industrial plant would be smoke-free from the start. Although the concept originated abroad, it was the Society which first pressed for its adoption by the UK. Finally, in the face of strenuous opposition from many quarters, the Society more and more criticised the domestic open coal fire as a major source of pollution. The arguments this inspired in the long run did much to spread a national awareness and acceptance of the case for clean air. In 1936 the headquarters moved back to London to be closer to central government and Parliament.

Though activities were severely cut when the war began in 1939, the Society was kept together and, although there were no meetings for some years, the journal continued to be published without a break. The Society produced yet another first - in 1942 - when it proposed that the new types of improved open grate then being developed, and which were suitable for any smokeless fuel, should be installed in all new houses - and that smoke prevention should be an integral part of any fuel policy. Before long the smokeless zone principle began to be accepted and one local authority after another included appropriate provisions in Private Acts. Because of the activity and interest stimulated by the Society there was a rapid growth in membership. A new constitution had been devised and attendance at Conference grew from pre-war levels of one or two hundred to four hundred and then on to over eight hundred. Divisional Councils were established in most parts of the country. This growth was in full swing when in 1952 the Great London Smog, followed by the Beaver Committee, focussed attention as never before on clean air. Even then, the processes towards a legal remedy were far swift. The excellent report of the Beaver Committee was consolidated in a Private Member's clean air Bill introduced by Gerald Nabarro, MP in 1954. MPs' support was overwhelming and the Bill was only withdrawn on the promise from the Government to put forward its own Act embodying thge necessary financial provisions. In 1956, 29 years ago, the Clean Air Act was passed. I was elected as a member of Middlesbrough Council the following year. This history of the Society now becomes a little more personal!

If you had visited Teesside 150 years ago you would have found a small hamlet containing but a few houses. The main shipping port was at Yarm and later at Stockton. With the advent iof the iron and steel works, Middlesbrough developed its own port - it is now the number 3 port in the country - and the town grew rapidly. William Gladstone said, " Here we see a new Hercules being born". In addition, one of the largest petrochemical and chemical complexes in Europe was established on

Teesside.

Such was the growth in the area by the late 1950s the town had the unenviable record of having the worst air pollution figures in the country outside London. At times the pollution was so great it was difficult to breathe and all around there was evidence of poor health - principally chest complaints - and the deteriorating fabric of our buildings - a state of affairs which the Council was not prepared to see continued. A 20 year programme for domestic smoke control was eventually started in 1960.

In 1958 the National Smoke Abatement Society became incorporated under its present name of National Society for Clean Air. Its work was cut out for it both nationally and locally. In the 50s and 60s there were major factors throughout the country opposing the spread of smoke control: disruptions in smokeless fuel supplies and cut-backs in local authority programmes. Using exhibitions, meetings and conferences, the Society exerted a constant pressure for progress, greatly helped by its strong local authority membership. Often it was individual Councillors or Officers whose active concern for clean air led their authority to join the Society, and who fought hardest for the cause both locally and nationally. For Middlesbrough, things did not go well in the early days. The date on which our first order was to come into operation had to be postponed for six months because the works manager failed to ensure that the necessary adaptations in the Council´s own properties had been completed.

In the north we allow any officer or member one mistake, but I have to tell you I do not recall his name. You can put your own interpretation on this event!

Over the next 20 years we were to encounter a number of problems, not least being the reduced capital allocations which could have slowed down and, indeed, even stopped our smoke control programme. This problem was most acute during the latter five years and I had many sleepless nights thinking about how we could overcome it. It was clear to me that were we to stop the programme we would have great difficulty in getting it restarted - if at all! There is no doubt that other areas of environmental health suffered reduced resources so that this ambitious smoke control programme could be completed as a first priority. The Chief Environmental Health Officer and myself agreed that whilst we would place Orders before the Council for approval in an unmodified form, we would have a contingency plan in our back pockets - a series of mini orders. However, our luck was in and we successfully completed the programme, on time, in 1980.

Whilst all this work was going on in the domestic field, our officers continued to work alongside the Alkali Inspectorate in order to ensure that industry played its part in ridding us of the scourge we had inherited. There will be no need for me to remind you that close co-operation and liaison between the Inspectorate and local authorities had always been a key element in the national approach to air pollution control - a co-operation that common membershipo of the Society did much to foster.

As has been the case with so many other towns and cities, these combined efforts produced a remarkable transformation. Now we have air as clean as the best seaside resort or spa town; you can see as far as the eye will allow; our chest hospitals have become redundant and the population is generally healthy. Nowadays, flowers and trees grow in profusion throughout the city - to the extent that 1983 we won the Britain in Bloom competition. Couplethis with the fact that we won the National Tidy Town Award in 1980 and you will perhaps realise that Middlesbrough has been transformed into a most desirable place to live.

Of course, many people and many organisations have contributed to this success. In particular I should mention the Boroughs of Cleveland Pollution Control Group which, like many comparable groups throughout the country, has enabled members and officers to come together to discuss transboundary pollution problems. Such has been the success of this group that it was highlighted by the Royal Commission on Environmental Pollution in their 10th Report as a shining example of what canbe achieved through such co-operation. The Government, in its response to the 10th Report, recommends other local authorities to follow the Boroughs of Cleveland example.

What then are my conclusions from this brief review of the history of the Society and the part played by my authority in its making? Above all, the first is that, despite so many notable successes down the years, so much remains to be done.

If we have removed much of the smoke from our atmosphere, then much remains - while that from diesel engines continues to increase. If we have reduced the amount of sulphur we pump daily into our skies, we have yet to understand and come to terms with the effects of the vast tonnages we continue to pour forth. We permit NOx and hydrocarbons emissions to increase with consequences that remain unclear. Overall, we live in a noisier, rather than a quieter environment. The list of examples is almost unending. The tragedy of Bhopal and the potential hazard of Three Mile Island remind us that legislation is not enough. And this brings me full circle - to the original objective of the Society's founding fathers - which was to ensure that as well as possessing the essential legislative controls, the nation also had the will to enforce them. We do have the backroom staff and members of the Society with a variety of experience and expertise and I have no doubts that their enthusiasm will tackle the many tasks that we as a Society will face in the future. Thus, if we are a learned Society - pondering the issues and the means of resolving them; if we are a forward-thinking Society - encouraging research and development; and if we are a teaching body - promoting public education in all matters relating to the value and importance of clean air; my overriding conclusion is that at heart we remain what we set out to be - a pressure group! This is something that 28 years in politics has taught me to understand. As John Ruskin once said:

> "God has lent us the earth for our life. It belongs as much to those who are to come after us, and we have no right by anything we do or neglect, to involve them in any penalties or deprive them of the benefit which was in our power to bequeath".

We must not rest on our laurels; we must be ever vigilant that we do not permit the same sorts of mistakes as were made in the past to be repeated in the future; and in pressing the case for clean air, we must take to heart John Ruskin's eloquent reminder that we have the Almighty on our side!

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– ACID RAIN –
UK ATTITUDES AND OFFICIAL POLICIES

– By –

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Rather than dwelling on the acid rain problem as a scientific problem (and as an administrator I am not well qualified to talk about science anyway) this paper looks more at the conflicting influences which have to be taken into account in policy-making in this country. I might also refer to the situation in other countries since this is relevant to the United Kingdom policy and perhaps speculate a little on future developments.

The history of air pollution control in the United Kingdom has been well described elsewhere notably in The Politics of Clean Air by Lord Ashby and Dr Mary Anderson. You will all be familiar with the development of concern about local air pollution in the United Kingdom which resulted in the setting up of the Alkali Inspectorate who were subsequently empowered to ensure that industrialists used the best practicable means to prevent polluting emissions. By 1970 the United Kingdom's air pollution control system had been operating for some hundred years. We had largely overcome local industrial pollution problems and we were well on the way to clearing up low level smoke from domestic sources in most major towns. It was at about this point - when it might be said that the United Kingdom was riding the success of its air pollution control policies - that the possibility of an international air pollution problem first emerged. The Swedish Government, concerned about the increasing acidity of rainfall and afraid that this might damage crops and fresh water fish, presented a report to the UN Conference on the Environment in Stockholm in 1972.

The Report's main conclusion was that the increasing acidity of rain in Sweden was caused by emissions, especially of sulphur dioxide, from coal burnt in other countries and carried across Sweden's borders. In the same year - 1972 - the issue was taken up by the Organisation for Economic Cooperation and Development (OECD) which commenced a programme to measure the long range transport of air pollutants in order to determine the relative importance of local and distant sources of sulphur compounds in air pollution. The results of this made it plain that long range transboundary pollution concerned the whole of Europe and this conclusion led in 1977 to the formation by the United Nations Economic Commission for Europe - the ECE - of the European Monitoring and Evaluation Programme (EMEP) which still exists today and of which the UK is a main participant. Meanwhile, separate negotiations in the ECE led to the formulation of the Convention on Long Range Transboundary Air Pollution which was signed in Geneva in 1979. This Convention provided for information exchange, monitoring and research to take place before the development of common strategies to deal with transboundary air pollution. Remarkably, despite needing 24 ratifications it came into force in March 1983.

Present international pressures spring in large measure from this Convention. Although there was agreement that it should be implemented before coming into force, the Scandinavian countries were unhappy with the Convention since it offered them only a remote prospect of agreement on action to reduce emissions. The Swedes therefore convened a conference on acidity in Stockholm in 1982. The conclusions of this conference did not take matters much further but the conference again highlighted international concern about acid rain and of greater significance was the occasion when the Government of the Federal Republic of Germany announced that it intended to introduce major legislation to control acidifying emissions.

This was a major change in attitude by the German Government which had hitherto taken the view that controls were not needed and it led indirectly to further international action both in the Economic Commission for Europe and in the Community. In the ECE the Scandinavians and Canadians joined forces with the Germans and others to form the 30% Club - those countries which agreed to reduce their total national sulphur dioxide emissions by 30% by 1993 on the basis of their 1980 figures. This proposition was given a boost by the Munich Conference convened by the German Government in 1984 which led to the negotiation of a protocol to the Geneva Convention formalising the 30% Club. This protocol was signed by 21 countries - but not the United Kingdom - in Helsinki earlier this year. In the Community, the Commission (responding as it often does to the tightening of legislation in one Member Country) prepared a draft Directive which would require Member States to reduce sulphur dioxide, NO_x and dust emissions from existing large plants - that is, mostly power stations but including some major industrial combustion plants - by 60%, 40% and 40% respectively. It would also require the imposition of tight emission limits for SO_2 and NO_x and dust on all new large plants. This Directive is still under negotiation.

This is a long catalogue but I think it is important, for an understanding of the Government's dilemma, to appreciate how the issue has developed internationally, as a political as much as a scientific problem. It is one of those matters to which Dr Holdgate referred in his paper at last October's Conference, which is being defined and analysed internationally. But in deciding what action to take other considerations of fact have to be taken into account. And some of these incorporate important domestic political considerations.

Perhaps the first question is what are the UK's and other countries' emissions and what may we estimate about future trends. International concern has concentrated primarily on SO_2 emissions and it is these which I will mainly consider. But I shall refer to NO_x emissions since these also contribute significantly to acidity and are now attracting greater political attention internationally. The UK's SO_2 emissions in 1984 were about 3.5m tonnes - although this figure has not yet been published. About 70% of these emissions were from power stations. This figure is to be compared with emissions of over 6m tonnes in our peak year - 1970 - and of 4.67m tonnes in 1980 which is the base year for the 30% club and the proposed EC Directive. On the published figures we are the largest emitter in the Community. Italy and West Germany come next in the list but their figures show emissions ½ - 1m tonnes less than ours on the basis of similar fuel use.

Of course the combination of our total figure and our location to the west of west European countries highlights our position.

As to the UK's emissions, there are a number of factors which suggest that the overall trend might continue down. There remains capacity for substitution of gas for other fuels and some coal-fired capacity will be replaced by nuclear for electricity generation. In addition, our industrial structure is changing and demand for electricity may not run at the levels of past years. Certainly in a period when GDP has grown, emissions have continued to fall. On the other hand, it would be rash, in considering policy, not to take account of the possibility that emissions might increase. And a number of scenarios based on present or reasonably estimated growth rates do point to the possibility of emissions increasing slightly over the next 10 years perhaps falling off again as rather more nuclear comes on stream in the early years of the next century. A judgement on emission trends has to be taken in the policy-making process. But, as can be appreciated, this is a difficult decision in itself.

The position on NO_x emissions is even less clear. The UK's present emissions are about 1.6m tonnes and are believed to have remained fairly steady for the past few years whilst those of other countries in Europe have been rising. West German emissions in particular are estimated to be double ours. But NO_x emissions are notoriously difficult to estimate and of course whilst SO_2 arises predominantly from a single source, NO_x is emitted in approximately equal quantities by power stations and vehicles with other sources contributing relatively little. Assessment of future trends is therefore even more difficult.

So what happens to our emissions? Where are they deposited? Here our information relates mainly to SO_2 and derives from EMEP. The main conclusion to be drawn from the Programme is that no country stands in isolation. All European countries to greater or lesser extent share each other's emissions. So far as the UK's emissions are concerned slightly more than 30% is deposited in the UK itself, some 40% in the sea and rather less than 30% is deposited in other countries. The 30% of our own emissions which is deposited in the UK represents about 80% of total UK deposition - that is, we receive some 20% only from other countries.

The picture for other European countries is rather different. In general a smaller proportion of their own emissions are deposited in continental European countries than is the case in the UK. So, for example, only 25% of Sweden's emissions appear to be deposited in Sweden and the remainder of their deposition comes in relatively small quantities from several other countries. The UK's contribution is estimated at 6% of Sweden's deposition which is about the same amount as that contributed by Poland and East Germany. But as is the case in a number of countries, the amount of deposition the source of which cannot be decided, exceeds all other amounts. The country which receives the highest proportion of its deposition from the UK is Norway, where UK-source deposition at 10% equals Norway's own contribution. Again, however, a lot of countries contribute to Norway's deposition and no less than 44% of their deposition is unattributable.

From these figures it can be appreciated that the UK's position does differ to some extent from that of other countries. On the assumption - which not everyone agrees with - that a cut in emissions will result in comparable reduction in deposition, even a large reduction in the UK's total emissions would make very little difference to the deposition burden in other countries.

A large reduction in total European emissions would of course reduce overall deposition rates. But generally western European emissions are declining as are those from the UK and indeed there are already some signs that deposited sulphate in Scandinavia is falling.

The picture for NO_x is probably very similar to that for

SO_2 except that West Germany is responsible for relatively more of the emissions so that there are likely to be some adjustments as a result of which the UK's exports will be relatively lower than those of SO_2. This is an issue which the Department is working on and we hope to have some answers soon.

The situation on emissions is therefore not as straightforward as it is sometimes represented. On the figures provided by Governments, the UK is indeed the largest emitter of SO_2 in western Europe and the second largest in Europe as a whole - although in terms of emissions per capita 9 other European countries are higher. We are not however the largest contributor to other countries' deposition - not only do four of the eastern countries exceed us in this respect but so does West Germany whose emissions contribute half as much again as ours to others' depositions.

I think this shows that, purely in terms of reducing deposition in other countries, the effectiveness of measures to reduce UK emissions at a greater rate than they are already going down would be questionable. I should stress that I am not commenting on the effectiveness of emission reduction in reducing environmental damage, which is quite another matter. I merely wish to illustrate that the figures do not reveal the UK to be the ogre it is sometimes called. And this is significant when policies are discussed.

Another aspect of the problem - and this receives surprisingly little attention - is that in reducing emissions other environmental problems might be created. Again I will concentrate primarily on sulphur. The major technology for abating emissions is FGD which needs limestone for the scrubbers. If, for example, FGD were to be installed at 12 major power stations, it has been estimated that some 2m tonnes a year of limestone would be needed. Now this is not a very large amount when set against the 90m tonnes or so a year already extracted by the mineral industry. But it is another 2m tonnes from upland quarries often in areas of natural beauty.

Indeed few limestone quarries are elsewhere because the limestone mainly occurs in these areas.

The limestone would of course have to be transported to the power stations and that would mean additional lorry movements in and around national parks and through urban areas between the source and the stations. I do not wish to exaggerate these effects but you will all know how many people are concerned about the environmental damage of mineral working in some areas and how many people are bothered by lorry noise and vibration.

Then there is the waste problem. Even on an optimistic assessment of the amounts of gypsum, elemental sulphur or sulphuric acid which might be sold as a by-product of FGD, a programme of desulphurisation at 12 stations would produce 2m tonnes a year or more of waste - a significant increase in the 9m tonnes or so a year already produced.

I do not suggest that these problems are insuperable but they would represent significant environmental problems in themselves. And they clearly have to figure in the policy consideration. If one environmental problem is to replace another, some attempt - insofar as the facts will support such an attempt - has to be made to ensure that the balance is right.

Now to costs. Again if we consider controls on sulphur emissions we must first think of FGD. Present estimates suggest that the cost would be some £150m for retrofit of FGD at an existing 2000 MW power station and about £1600m for a programme of FGD at 12 stations. These are significant sums. And the cost of reducing NO_x emissions - by use of low NO_x burners - might add a further £250m. But these burners would not meet the Directive's full requirements. Obviously if controls were retrofitted at fewer stations capital costs would be lower and the effect on electricity prices might be relatively small. But action to meet the EC Directive might add 5-6% to the UK's electricity bill. And the sums involved are certainly sufficiently large to be a major consideration in any decision making process on policy.

There is of course the other side of the coin - the costs to the environment. Here, as is often the case, costs are almost impossible to produce. Various attempts have been made, and I am sure many of you have seen them quoted, but those who have made these attempts have generally acknowledged the inaccuracy of their figures. It is also noteworthy that most such attempts include the costs of all known damage from emissions, both that caused by heavy local pollution and that which may be attributable to long-range pollution. Little attempt has been made to isolate the effect of long-range pollution and in truth it is difficult to see how it could be done with any degree of accuracy.

If we cannot cost environmental damage we none the less have to take some view about the effect of acid rain on the environment and perhaps more importantly try to assess what future effects might be. In the northern hemisphere where about 90% of both sulphur dioxide and nitrogen oxides in the air is man-made and where the man-made proportion of these gases has exceeded nature's contribution for a century or more, the effects are even now difficult to isolate from effects of other activities.

The Society's own policy paper published in September pointed at some of these problems. Perhaps the best known effect is that on fresh waters. We know about the effects on areas of poor neutralising capacity such as southern Scandinavia. Similar effects appear to a minor extent in the UK notably in Galloway and we have some evidence to suggest that acidification started at the time of the industrial revolution.

I think it is fair to say that fresh water acidification is a real problem and that it does damage fisheries and other life in fresh water lakes but that the problem is localised. We do not know, however, what other areas of the world might be at risk. Nor can we assess what the effect might be if the whole world's emissions were largely dispersed - we must remember that it is only in the last 20 or 30 years that North American and European emissions have been dispersed. Before that, local pollution was severe in many countries and its effects are still being felt.

Forest die back is a different matter. Damage is certainly occurring in large tracts of central Europe but we are still some way from identifying the cause. Acidity is a possibility but damage occurs in a wide range of soils so that it does not seem likely as a general explanation. Climate and stress from exposure also seem to be possibilities as do attacks by insects and fungi. The fifth possibility is ozone damage - there is clear evidence from the United States that ozone can damage trees and levels of ozone in central Europe are known to reach levels similar to those which occur in the United States.

So air pollution is clearly involved but whether it is the main factor or not we do not know. At present in the UK we do not seem to have the problem but it is certainly not an issue for complacency and the Forestry Commission are undertaking a number of studies to establish whether damage is occurring to an undue extent.

Material and notably stonework damage is the third area which is generally discussed in this context. The reduction of local pollution is undoubtedly relevant here and the indications are that the rate of building corrosion in the UK has declined since the measures provided for in the Clean Air Acts took effect. If damage to buildings is on the increase (and we have no conclusive evidence to this effect) it seems unlikely that emissions from stationary sources are the cause. The emissions which have grown in recent years are those from motor vehicles. But this again is an area where research is being undertaken both as part of the Department's programme and by others.

There may be potentially very serious environmental risks in failure to reduce emissions further and further than they are already declining. The risks are unquantifiable yet they must be taken into account in the policy process.

Finally there are the wholly political considerations. It is undeniable that those countries, including the UK, which have not joined the 30% club, are receiving a bad press in those countries which have. And this of course lends a diplomatic dimension to the problem. Within the UK, however, although many people are concerned about acidity, I think it is fair to say that air pollution is of less concern generally than is, for example, preservation of the countryside. These are again very difficult issues which have to be weighed against all the other considerations.

With certain changes of emphasis it is this mix of considerations which has to inform all countries' decisions. In the UK the fact that we have already achieved substantial emission reductions which we would expect to see continue in the future with changes in energy supply and with new vehicle emissions requirements, has weighed heavily when set against the costs of controls and the emerging results of our research. In some other countries where damage has been more pronounced and where domestic political pressures have been greater, it has been decided that further steps should be taken immediately. Few countries however have an extensive control programme and it is possible that the decline in emissions will prove to be fairly even across the board in western Europe at least.

As to the future, the Department is putting a lot of resource - some £3.5m a year - now in its air pollution research programme. It would be rash to suggest that the results of this - which we expect to see coming through in the next year or so - will "prove" anything. We continue however to gain better insights both into the atmospheric processes which give rise to acidity and to the effects.

Similarly in the case of control technologies, we are looking for improvements. Combustion technologies do not emerge overnight but, especially in the case of NO_x emissions, we hope that more effective and cheaper solutions than those presently available may emerge.

Meanwhile, there are signs that the pattern of energy demand may be changing and we may use less fossil fuel to supply that demand. As I suggested earlier, this is a difficult area and much depends on growth and more particularly the type of growth which occurs in the UK and other countries.

Lastly I can only say that interest in the issue at international level continues unabated and I strongly suspect that acid rain will be an object for discussion at the Society's Conferences for some years to come.

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CONTROL OF ACIDIC EMISSIONS FROM STATIC PLANT

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CONTROL OF ACIDIC EMISSIONS FROM STATIC PLANT

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INTRODUCTION

This paper reviews recent developments in the control of sulphur dioxide and nitrogen oxides (jointly referred to as acidic gaseous) emissions from stationary sources which have occurred in Europe. It considers any implications that these might have for the United Kingdom. The focus is on both technical and policy developments and special attention is given to those circumstances which are especially important from the local authority perspective. Hydrocarbon emissions will not be considered in this paper since their emission is only to a small degree related to the combustion of coal, which is the main topic of this presentation.

PART I

Emission Control Policies

Before beginning the technical examination it is worthwhile summarising the current situation on the policy front. Anyone who travels frequently in NW Europe cannot help but be aware of the widespread hostility towards the UK regarding its position over matters such as subscribing to the '30% Club' (see below). The intensity of criticism, even in official government publications, is notable (Statens Naturvaerdsverk, 1984). It is felt that the UK's reluctance to join other western European countries is undermining the development of a common approach to the countries of eastern Europe, whose emissions are, for several of the European mainland countries, of greater significance in their national deposition budgets than those of the UK.

The UK position on emission control is essentially based on two arguments:

1. there is still uncertainty about the complex pattern of causality of acid deposition and its consequent impacts

2. the cost of any control programme to achieve the called for percentage reductions will be significant.

In response to these points, European countries have argued that uncertainty about the exact nature of acidic impacts should not rule out present activity to reduce emissions because this should be treated as an insurance policy taken out while there is still time to minimise further or even reverse existing damage. They can also point to a remarkable willingness on the part of the general public to accept the inevitable cost implications of control technologies. For example, there is one area in the Federal Republic of Germany where the installation of very sophisticated SO2 control systems implies an increase in consumers' electricity rates of about 25% over a period of a few years. There has however been no expression of concern about such a figure by these consumers (BKB, 1985).

The overall policy situation in most countries of NW Europe has been that a conclusive cost-benefit analysis justifying emission controls has not been required before regulations have been introduced. Provided that the necessary control technologies are technically reliable (with reliabilities equivalent to those of their associated plant) and not economically crippling to the enterprises concerned (a condition about which there has sometimes been argument within Europe) then they have been required to be fitted (Torrens, 1985).

The UK position is that it is a general policy aim to achieve a 30% reduction in national SO2 and NOx emissions from their 1980 levels by the end of the 1990s but that it is difficult to achieve this by the early or mid 1990s - the pledged goal of members of the '30% Club', (for SO2 alone, at present). UK policy statements have implied that this reduction will be achieved by passive means such as changes in the energy economy, in the mix of fuels combusted and by energy conservation. Recent work on energy consumption projections does however suggest that it may well be difficult for the UK to achieve its own policy goals by passive means alone, which raises some difficult questions for further consideration (Skea, 1985). Government statements to the House of Commons Select Committee on the Environment in November 1985 have shown that these doubts are recognised officially.

Another strand of UK policy has been to emphasise the reductions in national SO2 emissions achieved since they peaked in 1970. UK SO2 emissions are now around 58% of 1970 levels and the UK government argues that the choice of 1980 as a base year for reduction targets is arbitrary and unfairly diminishes the significance of the UK's SO2 emission reduction compared with the pattern of several European countries over the same period.

The aims of the '30% Club' have already been mentioned and this is an appropriate point at which to clear up some of the confusion which exists between this particular initiative and the totally independent proposal in the form of a draft directive on emissions from large (>50MW thermal) combustion sources which has been put forward by the European Commission.

The '30% Club' is based on the activities of the United Nations Economic Commission for Europe, which brings together the countries of eastern and western Europe, Canada and the USA. Participating countries have agreed to reduce their 1980 national SO2 emissions by 30% as soon as possible or by 1993 at the latest. In some cases (eg the Soviet Union), the agreement is to reduce transboundary flows alone by this 30% figure. The agreement does not at present involve commitments to NOx emission reductions - these are currently the subject of negotiation.

The European Commission's 'Large Combustion Plant Directive' is currently the focus of intense debate between member states of the Community. The latest form of the Commission's proposals are as in table 1. During 1985 the European Commission came forward with some modifications to the directive as originally published, largely as a result of recommendations made to it by the European Parliament (Commission of the European Communities, 1985). These amendments have increased the severity of the draft directive and have introduced an intermediate category in the size classification of emission performance standards for new plant - between 100 and 300 MWt.

The significance of the introduction of this new class of plant for the UK situation is difficult to assess - it will depend on future construction plans for units of this size. These will be for the industrial heat and steam sectors or possibly for combined heat and power/district heating schemes. It is worth noting that the amended draft directive actually imposes a more stringent SO2 emission limit on coal-fired facilities than it does on liquid-fuelled plant in this size category.

As table 1 shows, the amended European Commission proposals also place on new solid-fuelled fluidised bed combustion (FBC) plants a requirement to meet a common emission standard irrespective of their thermal rating. This emission standard is identical to the most stringent (over 300 MWt) size requirement on conventional furnaces (<400 mg/Nm3), at least for the period up to the end of 1995. The Commission still has to decide its emission limit proposals for FBC plant for the 'second half' of the directive's time frame, after the end of 1995 but there is no indication that these will be any less stringent. The reasons for selecting these punitive emission requirements on an emerging technology which stands a good chance of capturing a major part of the new furnace market in Europe are unclear. The Commission does seem to subscribe to an approach which goes beyond the concept of 'best available control technology' to 'technology forcing' whereby standards are set outside the limits of current technologies to encourage technological development.

The response of a person concerned with air pollution policy from a local authority setting might be that, interesting though these developments are, they are essentially matters of concern for organisations other than their own. The international debate will be conducted in distant centres such as Geneva, Helsinki and Brussels, with jockeying for a favoured outcome being the concern of the Department of the Environment, the Central Electricity Generating Board, the Industrial Air Pollution Inspectorate and the

Confederation of British Industry. From this viewpoint, the local authority can afford to stand back and observe with benign neutrality whether the acid deposition dispute is resolved or remains in a state of impasse.

However, observations on what has happened within Europe in the recent past (in particular in West Germany, Austria, the Netherlands, Denmark and Sweden) suggest that this may be a somewhat mistaken interpretation. There are some general rules which can be put forward regarding the evolution of national emission control policy:

1 pressure develops for any emission limits first formulated as new source performance standards to be applied to existing plant as well, or at least to existing plant with any significant likely future lifetime, sometimes with provisions for a period of grace before the emission limits must be applied;

2 pressure develops for emission limits first formulated for larger plant to be applied to plant of smaller and smaller sizes; (The European Commission has recently implied that it sees this as the next stage in development of European air pollution policy after the resolution of the large combustion plant controversy.)

3 there is a resort to various informal means to achieve compliance with stringent emission limits. National, legally-defined emission limits may not represent the most rigorous requirements facing a plant operator in actuality. A type of 'ratchet' occurs. Where local authorities wish

> to impose emission limits more stringent than national limits, they usually get their way. Conversely, in those few cases where local authorities have sought to impose less stringent controls because of a fear of undermining the economic viability of an enterprise, they have usually lost the attempt to obtain a special dispensation in this way.

All these trends suggest that there may well be an expectation on local authority agencies to play a greater part in the policy debate on emission control. This expectation could be increased by several other developments.

Although the initial impetus for more stringent emission control policies has come from concern over longer range, mainly international, pollution impacts, more recent work has seen some emphasis switching to local impacts, notably building damage. The extent of such local impacts and the origins of any emissions causing them are still the subject of considerable uncertainty but the increase in concern will almost certainly raise the expectation on local authorities to have a policy viewpoint.

Another development has been the increased recognition of the problems of managing solid residues and aqueous discharges from installation of flue gas cleaning equipment. In the majority of cases solid wastes resulting will require landfilling and this immediately falls into the province of local responsibility. There have been several disputes in European countries between utility operators and local authorities over waste disposal practices.

The most recent area in which local authorities have become increasingly involved in emission control policy concerns the operational safety aspects of some types of gas cleaning technologies, especially those employing ammonia (NH_3), as is the case with one type of flue gas desulphurisation (FGD) system and most flue gas denitrification systems. In the Netherlands, local authority concern about possible NH_3 leakage affecting a summer recreation site near a power plant led to rejection of an NH_3-using FGD system, while in Austria, one local administration has vetoed road transport of NH_3 into a power plant site.

Of course, in most European countries, local authorities formally play a greater part in the operation of locally-based electricity utilities than is the case in Britain. For this reason, there is a greater requirement on them to be involved in emission control policy. However, it is reasonable to argue that in the UK, local authorities will increasingly be expected to have a knowledgeable view on regulation of emissions from facilities in their area, even if they are not statutorily responsible for setting and administering emission standards. Where local authorities become involved in local municipal enterprise schemes involving new combustion facilities (eg some of the various schemes for combined heat and power/district heating under consideration in British cities) they are even more likely to need to develop a competence in emission control policy.

PART II

Sulphur Dioxide Emission Control

The past two years have seen the rapid deployment of FGD units throughout Europe and the placing of orders for even more, especially in West Germany. While the majority of these have been for new plant, several plants already under construction have had their commissioning dates set back to enable them to be retrofitted with FGD equipment.

Most of these FGD plant are, or will be, conventional 'wet' systems using limestone, or lime, as the input reagent and producing gypsum as a byproduct, with the intention in most cases that the gypsum will be used, although market opportunities for gypsum will inevitably diminish as more and more units start up. It is worth noting that nowhere in Europe are sulphite sludge-producing FGD systems in use, as is the case in the USA, and the image of FGD which has come from the US deployment of such systems is not relevant in the European context.

As well as these conventional systems there have however been five regenerable Wellman-Lord type FGD units ordered, including a very sophisticated linked system on two stations in West Germany, which will share a common SO2 sorbent regeneration unit. An order has also been placed in West Germany for the first full-scale FGD system using activated carbon for physically adsorbing the flue gas SO2, with the advantage that the system does not require any process water.

These developments mean that Europe is rapidly accumulating a considerable body of experience with regenerable FGD. However, in each case where such systems have been ordered, rather special, site-specific reasons (such as an onsite market for concentrated SO2) have determined the decision to use them. It would be wrong to imply that regenerable FGD systems have become a standard option. The main implication that this European experience has for the UK relates to the stated choice of Wellman-Lord regenerable systems for about 50% of the CEGB's units which would require fitting with FGD in the event of the European Commission directive being adopted.

Spray drying type FGD systems, in which the input medium is a concentrated lime slurry and the output a dried spent sorbent, mainly calcium sulphite, have also begun to break into the European market with systems operating in Sweden, ordered in Sweden and West Germany and under construction in Austria. It has been widely expected that such systems, which offer very limited opportunities for utilisation of the spent sorbent, would be at a disadvantage compared with gypsum-producing systems and this has generally proved the case to date.

Finally, during 1986, trials will go ahead with the first fully dry flue gas injection FGD system to be tested in Europe, using sodium bicarbonate injected into the flue gas in conjunction with a fabric filter type of particulate capture system. This system, to be installed on the St. Andrae II plant of Oesterreichische Draukraftwerke in Austria, has been made feasible by the imposition of tightened _particulate_ regulations (<30 mg/Nm3). These encouraged the utility to retrofit a fabric filter to its power plant and this having been decided it was realised, when subsequently SO2 emission controls were also tightened, that a combination of in-furnace injection of limestone and _flue-gas_ injection of NaHCO3 could exploit the SO2 absorbtion which has been observed with SO2 sorbent cakes on the fabric filter surfaces to achieve over 80% reduction in unconstrained SO2 emissions.

Turning to smaller-scale facilities, there has been some European experience with FGD plant fitted to units as small as 4 MWt. At this scale, liquid scrubbing plants may be an attractive proposition, since they do not present insuperable waste water management problems and avoid the need for solid waste management. However, FGD units are not likely to be the preferred SO2 emission control option for smaller-scale units and regulations generally do not require the percentage reduction in unconstrained emissions on smaller units (<50 MWt in general) which necessitate FGD. Consequently, a considerable body of European experience is now accumulating with fluidised bed combustion units, using in-bed limestone for SO2 capture and achieving up to 80% reduction in unconstrained emissions.

Fired not only with coal but with various forms of waste-derived fuel and usually offering an attractive flexibility in their fuelling possibilities, these plants seem now able to offer economic attractiveness as well as environmental advantages. The co-disposal of fluidised bed combustion wastes along with conventional municipal waste on local authority operated disposal sites does not seem to have given grounds for concern in Europe.

Nitrogen oxides emission control

The increased attention given to nitrogen oxides emission control is perhaps the most notable feature of the European emission control scene over the past year. In both West

Germany and Austria new power plants scheduled for commissioning have had their start-up dates postponed to allow retrofitting of selective catalytic reduction (SCR) type denitrification units. However, for smaller and older plant, the emphasis has been on various forms of combustion modification to reduce formation of thermal NOx (formed by temperature-related oxidation of atmospheric N2). In Britain, the CEGB has begun trials of burner modifications to reduce NOx formation in its corner-fired boiler units and similar work will be carried out to test the potential for burner modifications on the larger number of wall-fired units in the CEGB system.

The European Commission draft directive's requirements for NOx emission reductions could probably be met within the UK by such furnace burner modifications, assuming that the CEGB were not expected to shoulder more than a 40% reduction of its own emissions, although modifications would be required to a larger number of stations than the 10-12 involved in FGD retrofitting to achieve the Commission's proposals for SO2 reductions.

It is too early to draw any definite conclusions about SCR denitrification from the European experience, except that utilities in the process of fitting units are apprehensive about their performance and reliability. In many cases, these apprehensions relate to technical features deriving from the fact that many coal-fired generating plants in Europe are operated in a mid-merit order position, with quite frequent start-ups and shut-downs. All the indications are that this operating mode will create demanding conditions for SCR operation.

SCR denitrification certainly cannot be viewed as a proven technology in the same way that FGD technology can now be described. For this reason, there is a strong interest in technologies which can jointly remove both SO2 and NOx from flue gases and many manufacturers of desulphurisation equipment have been looking at process modifications which may offer a respectable level of NOx reduction. So far the only commercial system of this type to have been ordered in Europe is the activated carbon (Bergbau-Forshung/Uhde) system being installed at the Arzberg plant in Oberfranken, West Germany.

Future Technologies

There are essentially two main technologies which are viewed as having the potential to replace conventional pulverised fuel fired electricity generation by offering both low emission characteristics and improved thermal efficiency - combined cycle pressurised fluidised bed combustion (PFBC) and combined cycle gasification (CCG).

The IEA/NCB/CEGB initiative in PFBC represented by the Grimethorpe facility is widely known about in the UK. However, in the past year the main development of interest in this field has been with the ASEA-developed Swedish PFBC technology. The electricity/district heating utility of Stockholm has announced its intention to commission a full-scale plant based on this technology for installation near Stockholm. The overall 'image' of PFBC will probably be critically dependent on the progress made with this facility*.

With CCG, the commissioning of the Coolwater plant at Daggett, California and the extremely favourable emission characteristics which this plant has displayed has been the most promising development in coal-using technologies of all types reported in the past year. However, the plant still has to achieve overall levels of thermal efficiency which would make the technology able to compete with conventional firing systems.

In fact, the overall message on new technologies is that convention very much dominates. The most promising technical development work at present is that devoted to sequential improvements in operating reliability and efficiency of conventional FGD sytems, of combustion modifications to offer appreciable reductions in NOx emissions and in the field of atmospheric fluidised bed combustion for smaller-scale facilities.

CONCLUSION

This paper has shown that if a society accepts the need to move to a low acid gaseous emission energy economy, as has been the case in most western European countries, there will be profound consequences for local authority administrations. Of course, such an energy economy has not yet become official British policy. One consequence of this will be that if it does so, British local authorities will be able to draw many useful lessons from the experiences of their European counterparts.

*After this paper was delivered it has been announced that the Swedish government's Environmental Franchise Board, which overviews the environmental acceptability of all major development proposals, has recommended rejection of the Stockholm PFBC proposal. This has mainly been on the grounds of lack of acceptability of coal handling and stocking at the particular site chosen for the plant but also because the Board did not consider the technology sufficiently proven.

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TABLE 1 Commission of the European Communities Draft Directive on Large Combustion Plant

Emission Limit values for dust, sulphur dioxide and oxides of nitrogen in waste gases under standard conditions, from new plant

Type of fuel	Plant size (MW_t)	Emission Limit values in mg/m^3 for:				
		D u s t	Sulphur dioxide (1)		Oxides of nitrogen (2)	
			From 1.1.1985	After 31.12.1995	From 1.1.1985	After 31.12.1995
SOLID	> 300	<50	<400 (3)	< 250 (4)	< 650 (3)	< 200 (4)
	300-100		<1,200	<1,200 (4)	< 800	
	<100		<2,000	<2,000 (4)	<800 as a rule but <1,300 for pulverised hard coal firing with extraction of fused ash.	<400 as a rule (4) but < 800 for pulverised hard coal firing with extraction of fused ash.
LIQUID	>300	<50	<400	< 250	<450	<150
	300-100		<1,700	<1,700		
	<100		<1,700	<1,700		
GASEOUS	>300 300-100 <100	< 5 as a rule but < 10 for blast furnace gas and < 50 for gases produced by the steel industry which can be used elsewhere.	< 35 as a rule but <100 for coke oven gas and < 5 for liquified gas		< 350	<100

1) Account should be taken of the proportion of sulphur trioxide in the waste gas.
2) Expressed in terms of nitrogen dioxide. Nitrogen dioxide need not be measured continuously if it accounts for less than 5% of total emission of nitrogen oxides. The proportion of nitrogen dioxide should then be simply calculated.
3) This limit value applies to all Fluidised Bed plants irrespective of thermal capacity.
4) For Fluidised Bed Combustion plants the Commission will make appropriate proposals later.

Note: The Commission has also proposed reductions in national 1980 emissions of SO_2 (60%) NOx and dust (40%) from plant over 50 MWt to be achieved by the end of 1995

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BRITISH AND EUROPEAN AIR POLLUTION CONTROL POLICY

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The letter inviting me to give this paper explained that because 'many now see the centre of momentum in policy making as across the Channel rather than in Whitehall, we should examine the consequences for Britain'. Although I do not think this short sentence fully describes what has been happening, I agree that such a review is timely. In this paper I start with a few general observations, then review what I believe has been a changing approach to air pollution problems and their solution, and end with a look to the future.

Although so obvious as to be trite, it is worth remembering that policies are formed as one component in a sequence of actions set out in Figure 1. Policies exist to solve problems or create opportunities: in the environment protection field almost always the former. Accordingly, a policy is likely to be only as good as the understanding on which it is based. Any of us can suggest a problem - and the newspapers confirm that this is a national pastime - but whether it is real enough to need action demands analysis, and very often research. Even then, what we do about it depends on judgement of priority, of scale, and of the most effective kind of response. Finally, people often assume that when you have adopted a Community Directive and backed it with the national laws required to apply it, you have solved the problem - but this is a fallacy. Without effective enforcement and without monitoring to check that the action taken really achieves the required objective, the process is incomplete and can be pointless.

I go through this because we often stress how our environmental policies in Britain and the other nine nations of the Community have evolved independently and have inherent differences. This is a historical truth. But the process of policy formulation just summarised is largely common. While we have independence, we therefore also have a parallelism of approach, and

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* The views expressed in this paper are those of the author and not necessarily those of the Department of the Environment.

this makes harmonisation possible. The trend of the past two decades has been towards the recognition that many environmental problems are genuinely international in scope - either because they extend across the territories of many states or because their creation and solution lock into and affect international trading patterns. The international dimension has therefore become established at several of the stages in Figure 1: in problem recognition (where the strong international traditions of science make it almost unavoidable), in the establishment of scope and priority, in determining the proper level for action, and in monitoring. Because engineering, like science, has a strong international dimension, the techniques available for pollution control are also the subject of international discussion - time and again "best practicable means", allowing us to move forward to control pollution in Britain at economically acceptable cost, has been imported from overseas. This trend has little or nothing to do with the Treaty of Rome. Indeed, if you look at the international measures that have affected the control of air pollution in the United Kingdom in the past decade, set out in Table 1, it is clear that EC Regulations and Directives are part only of a host of international actions that variously bear on us and on the other member states of the Community. A key question we in the EC need to ask ourselves is not just how far the centre of momentum in environmental policy making has passed already from national capitals to Brussels, but how far it is likely to pass outside our ten - or twelve - member states in the next two decades.

CHANGING PERCEPTIONS OF ENVIRONMENTAL PROBLEMS

A major factor behind the increasing internationalisation of our approach to air pollution has been a changing perception of the underlying problems. As Lord Ashby and Dr Mary Anderson have so clearly brought out in their book 'The Politics of Clean Air' (1981) the initial concern in Britain as in other industrialised European nations was with acute nuisance from furnaces and other industrial plant. This pollution caused obvious but local damage and could be dealt with by specific, and in many cases local, measures. The first regulatory Act, in 1821, was restricted to furnaces generating steam: later measures in 1825 and 1842 were applied to the towns of Derby and Leeds, and the 1863 Alkali Act was specific to the one industry. The decentralised approach to the control of smoke and other air pollution nuisance was continued under the 1936 Public Health Act and the 1956 and 1968 Clean Air Acts, which laid enforcement responsibility on Local Authorities, and these also had the protection of public health as their first objective - which is not surprising since the Act of 1956 was directly triggered by the excess deaths in the London smog of 1952/53 and the findings of the Beaver Commission set up to investigate that tragedy (Beaver, 1954). The approach to industrial pollution under the 1863, 1872 and 1906 Alkali etc. Works Regulation Acts was in contrast centralised, with enforcement remitted to a professional Inspectorate, but the scope of this legislation was extended by Ministerial modification of the list of scheduled works in a relatively piecemeal way, as it was considered necessary, and the Act is also distinctively British in enshrining the principle of 'best practicable means' rather than setting fixed standards to be met by polluting industry. A third approach, also centralised but requiring observance of statutory limits, is provided by the control of vehicle emissions by Construction and Use Regulations made by the Secretary of State for Transport under the 1972 Road Traffic Act (McLoughlin, 1972: DOE, 1976).

However untidy it may appear, there is no doubt that this British legislative and administrative structure has had successes to claim. Virtually all the improvements that have been made in air quality in the United Kingdom have resulted from these domestic measures: despite their increasing number, the impact of Community Directives has so far been negligible in comparison. The changes are too well known to this audience to need elaboration: the 85% reduction in national smoke emissions between 1955 and 1984, the 37% decline in national sulphur dioxide emissions between 1970 and

1984, the restoration of winter sunshine to urban centres, the surprising stability or even slight decline in national nitrogen oxide emissions, the decline, soon to be dramatically accelerated, in lead emissions from vehicles and the decline in deposited grit, dust, zinc, arsenic, lead, vanadium and other metals at a number of sites (DOE, 1983).

We should not be too smug about these successes, welcome though they are. The fact is that many other European countries have a similar tale to tell, even though in most of them the down-turn in SO_2 emissions came later and some have seen rising NOx curves. Moreover, the UK remains at the top of the league of western European sulphur dioxide emitters even though the gap has narrowed, and we have accepted internationally - most recently at the Conference in Munich in June 1984 - that we need to do more. Another reason for caution is that only part of the improvement can be credited to legislation and regulation. Changes in fuel mix and combustion process, with the substitution of natural gas for coal and central heating for old fashioned grates, the development of nuclear power, energy conservation, and industrial renewal (some of it forced on us by recession, with its associated hardship) have all contributed. Table 2 is an estimate of the relative contribution of these several causes to the recent reduction in sulphur dioxide emissions, and tells its own story.

In any event, we stand now on the threshold of a radically different world. First, the dominant principle behind air pollution control policy has been changing. A decade ago, there was no question that protection of public health against direct threats came first, second, and third, with other aims way back in the field.

Our concern was with acute hazard, in urban 'hot spots'. The whole thrust of the National Survey of Smoke and Sulphur Dioxide, operated by local authorities under the co-ordinating hand of the Warren Spring Laboratory (1972), was towards monitoring conditions in the areas where people were likely to be most at risk. But today attention has become focused on the threats to man and his life-support system, as constituted by the wider environment - and with longer term hazards we have only recently perceived. Consider the list in Table 3 of the air pollution issues most debated internationally at present. Only two entries - benzene as an additive to motor fuels, and lead and other airborne metals - are regarded as predominantly of concern because of possible direct human health effects (and airborne metals also feature in the marine pollution story). Two of the issues - the impact of carbon dioxide on climate and of chlorofluorocarbons on ozone - are truly global and very long term. Two more - the effects of combustion products and secondary pollutants in acidification, forest damage and the corrosion of monuments - are regional and probably exert many of their effects on a time scale of decades. There is evidence that acidification changed the microflora of several Galloway lakes between 1850 and 1890, that fishery decline in some southern Norwegian salmon rivers began between 1900 and 1910, and that tree growth in parts of Germany (and the USA) was checked over a decade before the more striking symptoms of die-back were observed. If the hypotheses that some of the effects are mediated through the soil, and involve the release of toxic aluminium ions to freshwater and in the zone around plant roots, are correct then again we have to expect changes to be cumulative over decades and equally slowly reversed (if reversible at all).

It is not my purpose today to go into these fascinating but complex problems. The point is that the issues listed in Table 3 impose constraints on our development of policy because:

(a) they involve large environmental systems, with many component factors, operating over long time scales: there is thus great complexity and real difficulty in establishing cause and effect relationships;

(b) nonetheless, they are arousing such concern that it is unacceptable to postpone response while we wait for research;

(c) there is no way these problems can be solved by action at national level, and most of them are too big for the EC to tackle alone either - although energetic Governments and a united Community can have a major influence on the decisions of a wider group of nations;

(d) any policy has to be sustained over many years, or even decades: consistency is therefore required over the life of several Governments, and this points to a bi- or multi-partisan approach.

CHANGES IN THE APPROACH TO POLICY

It follows that we must expect - as the organisers of this Conference clearly saw - that the development of British policy for air pollution is going to change in the coming years. I suggest that this change will affect virtually all the steps in the sequence in Figure 1, namely:

(a) definition of the problem;
(b) analysis of the causal mechanism;
(c) evaluation of priority for action;
(d) establishment of the appropriate action;
(e) definition of subsequent monitoring.

The definition of environmental problems requiring consideration by Governments is already very much an international affair. At global level the United Nations Environment Programme has undertaken one major evaluation of the trends in the world environment between 1972 and 1982 (UNEP, 1982) and is now embarking on the collection and regular publication of statistical data on a series of 'environmental indicators' that will support analyses of changes in the biosphere and what they mean. The Executive Director of UNEP also provides regular reports to his Governing Council on the state of the world environment, and since 1974 these have highlighted particular problems (Table 4 lists the topics covered up to 1981). From such evaluations come decisions on the priorities for action in the UN System Wide Medium Term Environmental Programme, which is a co-ordinated action involving all the UN Agencies. Within the western developed nations, OECD also produces State of Environment Reports and discusses priorities in the Environment Committee. ECE, as the UN Regional Commiss Commission for Europe(also attended by the USA and Canada), has a Committee of Senior Advisers on Environmental Problems which discusses priority issues: this body was instrumental in the negotiation of the 1979 Geneva Convention on Long Range Trans-Boundary Air Pollution. The seven nation western Economic Summit meetings (in which the President of the European Communities participates) have recently included environment as a theme. The London summit in 1984 agreed that the Environment Ministers would jointly identify environmental issues with priority for international cooperation, while an official working party would consider how the collective scientific and technical expertise of the seven summit countries might be applied to problems of carbon dioxide and climate, acid deposition, radioactive waste disposal, marine pollution, and the technology for abatement of sulphur and nitrogen oxide emissions. In Europe, the Commission of the EC has organized expert meetings on how to apply collective scientific understanding to the formulation of Community policy generally (in Rome and at Evry, near Paris, in 1981) and to the specific issue of acid deposition (at Karlsruhe in 1983). Individual Governments have also convened special meetings, like the conference on acid deposition at Stockholm in 1982, the conference of nations already pledged to a specific abatement of sulphur dioxide pollution at Ottawa in 1984, and the joint German-ECE Multilateral Conference on the protection of freshwater and forests from acid deposition at Munich in June 1984. The non-Governmental scientific community has also convened numerous international meetings on environmental themes, including two Royal Society Discussion meetings respectively on Pathways of Pollutants in the Atmosphere (1977) and the Ecological Effects of deposited Sulphur and Nitrogen compounds (1983). It is now simply unthinkable that any major environmental problem will be diagnosed and dealt with solely on a national basis. The environment has become a significant component of diplomacy.

This trend has brought with it a need to harmonise - or at least translate - concepts and approaches. It is generally agreed that the best available scientific knowledge needs to be brought to bear - but the fact is that the data base available for this purpose is (as the UNEP Report on The World Environment, 1972-82 put it) 'of very variable quality' .. with .. 'startling gaps and a special lack of reliable quantitative information about the environment in the developing world'. At the simplest level, interchange of specimens has revealed that laboratories in different countries vary alarmingly in their capacity to analyse contaminants or measure variables like acidity. Some of the problems of interpretation of acidity trends have been aggravated by the fact that even using comparable modern apparatus, on a single water sample, measurements by different people can vary by up to 0.3 of a pH unit (or a factor more than 2) - while historically, the change from colorimetric to electrometric methods between the 1950s-60s and the 1970s-80s introduced a larger perturbation. Closer links in the planning, execution and interpretation of research could do much to improve scientific agreement on the nature of environmental problems. This is one reason for welcoming the recently agreed joint programme on the acidification of freshwaters in Scandinavia in which the Royal Society is collaborating with the Norwegian and Swedish Academies of Science. It is equally why the EMEP network on European monitoring and evaluation of pollution, which supports the ECE Convention on Long Range Trans-Boundary Air Pollution, is so important.

However good the field research and monitoring, however, we are bound to have incomplete data on which to base the analysis of problems as large as those in Table 3, and we require mathematical models to explore the likely workings of the systems involved. Modelling of the possible impact of carbon dioxide on climate is already well advanced, and some 34 such models are listed in one recent review (Clark, 1982). Modelling is less complete in other areas, like acid deposition. It is important that there is international evaluation of the structure and credibility of the various models, all of which make assumptions which inevitably affect their outputs. Beyond this again, all evaluations of such problems move into the territory of risk assessment, itself a growth area for scientific meetings and popular publications. Risk assessment has two steps: an initial statement of probabilities of effects following from causes (which can be objective), and a subsequent consideration of the social significance and acceptability of a possible event (which inevitably brings in subjective components). These matters have recently been explored in two Royal Society publications (1981, 1983) and by the Royal Commission on Environmental Pollution (RCEP, 1984). The latter analysis demonstrates that some familiar hazards with quite high risk - like motor cycling, mountain climbing or drinking - score low on the axes of fear and uncertainty whereas nuclear power, which objectively involves very low risk for the public, scores high on both axes. Policy making cannot ignore public perception, because one business of governments is to promote quality of life, of which confidence in the safety of the environment is an important part. It follows that where we are increasingly making policy internationally, differences in public perception from country to country or section to section of a community can impose conflicts.

In the European Community a difference in perspective, cultural values and experience has probably contributed to differences in the priority assigned to acid deposition by different member states. In the United Kingdom people have been most conscious of the success of the Clean Air policy in removing gross industrial contamination so that cities like Manchester, Leeds or Sheffield now sparkle in winter sunshine - and coniferous trees, which formerly grew badly if at all in the polluted South Pennines are now doing reasonably well (Lines, 1984). At the same time, until recently there has been little or no scientific proof of damage attributable to acidification of fresh waters or air pollution impact on forests in the UK, and little published data on the scale of acid deposition.

There was thus little public perception of the problem. In contrast, Scandanavians have been reading about the loss of fish, and impoverishment of freshwater biota in the south of Norway and Sweden for over a decade, and have been increasingly irritated at the British dismissal of responsibility for emissions which the OECD 1972-1977 study indicated could account for some 19% of all sulphate deposition in southern Norway and 9% of that in Sweden (Sweden, 1982). In contrast again, public opinion and Government action in the Federal Republic of Germany was relatively quiescent on this issue until 1981 or 1982 when the first strong evidence of forest dieback that appeared to be related to air pollution emerged. The dramatic jump in the damage statistics from 8% of stands affected in the 1982 survey to 34% in 1983, coupled with the particular importance of the forests in German economy, literature and culture, was enough to swing Government policy towards a massive investment in action to abate air pollution and a major campaign to secure comparable action throughout Europe. Table 5 summarises the steps in the definition of the acid deposition problem, and shows the length of time that elapsed between the initial scientific analyses and the burst of recent international and national actions.

The lesson from this is, I think, straightforward. If we are going to diagnose and analyse problems at international level, we shall also have to evaluate priorities for action at that level - especially where many nations collectively contribute to the overall situation, as they do with the phenomena listed in Table 3. This in turn means that just as, within a nation, interests are balanced in determining policy and some groups of citizens find themselves constrained or charged for the benefit of others, so internationally some nations that are not sufferers from a pollution problem may find themselves contributing to a common action for the benefit of those that are. It is not unreasonable to suggest an eventual extension of the 'polluter pays principle' to the effect that nations should share the cost of action to abate an international environmental problem in proportion to their contribution to its cause.

The theory should be one of genuine cooperation for mutual benefit. This implies, above all, honesty and equity in international dealings. It implies openness in sharing scientific data and evaluations. It also implies cooperation in the search for technology that can be applied to abate priority pollutants. Why should not there be a consultative process among the technical experts in the EC to determine "best practicable means" on a Community basis, thereby ensuring that we solve our collective problems at least cost? But if we are to move forward in this way we shall have to renounce the manoeuvring for position that can be seen from time to time in Europe, in which the environmental protection measures pressed by some Governments coincide remarkably with those that will give the greatest competitive advantage to their industries.

International agreements will, in my view, increasingly determine the priorities for action on environmental problems. But the process can be taken too far. It is important to define the geographical scope of a problem accurately and involve no larger a group of nations than is needed for its solution. In practice, the terms of the Treaty of Rome mean that any problem affecting more than one or two EC nations is likely to be dealt with at Community level (it is conceivable for the UK and Ireland to sort out problems confined to the Irish Sea on their own, or the riparian nations along the Rhine to deal with that river, but these are probably exceptions). But there is little point in involving the Mediterranean nations in the management of the North Sea, or North America (other than as experts and aid donors) in the Sahel. Business efficiency indicates that we should bring together those truly sharing the problem, but go no wider than we must.

I believe that there is also a misconception in a statement like 'the centre of momentum in policy making is now across the Channel'. It seems to imply that national Governments in Britain, as in other member states, have to sit back and await the Community's initiatives. This is a fallacy. While only the Commission can propose legislation to the Council, any member state can propose an initiative, and if the Council and Commission agree, legislative suggestions will follow. The UK Government took such an initiative in October 1979, when the Secretary of State for the Environment wrote to the President of the Commission asking for a Community ban on the importation of all whale products. More recently the UK Government addressed a proposal to the Environment Council calling for the withdrawal of lead additives from petrol. The German Government has taken powerful recent initiatives in calling for stringent standards for air pollution emissions from large combustion plant and vehicles. The implicit consequence for Britain as for any other member Government is to 'think European' when a new environmental policy appears desirable, and cast it from the outset in a form that not only meets national needs but is likely to carry Community support.

Decentralisation to national level will inevitably operate for most of the executive actions to deal with environmental problems, even where the legislative foundation is international. In the European Community it is noteworthy that most environmental measures have been adopted as Directives - that is, although binding on member states as policies, they are put into effect through national legislation (Haigh, 1984). In the United Kingdom, following a Government undertaking in response to the 5th Report of the Royal Commission on Environmental Pollution, we are engaged in a review of national air pollution legislation. I hope that a Consultation Paper will be issued by the end of 1984. New legislation is already required to implement the European Directive on air pollution from industrial plants, which was agreed in March, and the opportunity will doubtless be taken to make any other necessary changes, for example in local authority powers. The content of this legislation will obviously be for Ministers to decide, but I would be surprised if the essentials of the present system, with the IAPI regulating that industrial plant whose control demands special technical knowledge, local authorities regulating a wide range of other polluting sources - not all of which are readily controlled by existing reliance on nuisance as a legal criterion - and the Department of Transport operating vehicle regulation, will be considered to require radical change.

This may be the point at which to refer to Nigel Haigh's view that international legislation is likely to alter the traditional relationship between central and local government. There is much in this view. In accepting Community and other international commitments the Government is accepting an obligation to see that these commitments are implemented, and this imposes obligations on local and national authorities. In the Federal Republic of Germany the consequences for the relationship between Federal and Land Governments have at times been substantial. But in Britain I do not see why we should not continue to implement the policies we accept internationally in a pragmatic and sensible way. Nor do I see why centralisation of negotiations need lead on to the centralisation of the implementing powers.

It is essential that any pollution control policy be properly monitored. There are two main reasons for this. First, policies that do not cure the problems they address are pointless and need to be altered or scrapped - and without monitoring it is impossible to know whether actions are working. Second, monitoring (provided its methods and findings are available for open scrutiny) provides confidence that all those on whom control responsibility rests are doing their job. In the European Community there is (at least among the British) a widely held belief that not all nations are as punctilious about enforcing actions as they are vehement in calling for them. Variants of this belief probably exist in all member countries, with different 'villains' featuring in the anecdotes. The point is that confidence in Community decision-making as an essentially honest system depends critically upon its being manifest to all that the various Directives are being applied in a reasonably consistent way, and monitoring has an important part to play in this (von Moltke, 1983). The actual collection of monitoring data is likely to continue to rest with individual states, but collective analysis, as with the atmospheric chemistry data collected through the EMEP system, is likely to prove increasingly the norm.

CONCLUSION : THE FUTURE

The main conclusions of this paper are:

1. that the definition, analysis, and response to major environmental problems is increasingly an international activity;
2. that while the EC is going to be a major forum for policy development in future, the wider international community is playing an increasingly prominent role;
3. that this does not mean that there is no scope for national initiative. It is open to any Government to use the international system to promote actions to which it attaches importance, and a positive approach of this kind may be more rewarding than an inherently responsive and defensive one;
4. that despite the increasing international formulation of problems and responses, much legal and all executive action for implementation will remain with national Governments and with local authorities and official agencies;
5. that monitoring, to demonstrate the effectiveness of actions and the proper degree of conformity with obligations, is certain to remain of fundamental importance.

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TABLE 1. INTERNATIONAL MEASURES AND AGREEMENTS AFFECTING ATMOSPHERIC POLLUTION. SOURCE: UNEP, 1982: HAIGH, 1984

LEVEL	BODY	SUBJECT	APPLICATION
Global	UNEP	Convention to protect the Ozone layer (1985?)	Possible EEC and UK legislation on CFC manufacture and use
	UN	Convention on the prohibition of military or any other hostile use of environmental modification (1977)	National Policy
	UN	Protocol to the 1949 Geneva Convention prohibiting methods of warfare intended or expected to cause widespread, long term and severe damage to the natural environment (1977)	National Policy
	WMO/ICSU	Agreements on the Global Atmospheric Research Programme (1967) and World Climate Programme (1979)	National Actions
	ICAO	Proposed regulations on emissions from aircraft	National Law
	ILO	Convention on Protection of Workers against occupational hazards due to pollution, noise and vibration (1977)	National Regulations under Health and Safety at Work Act
	INTERNATIONAL CHAMBER OF COMMERCE	Environmental Guidelines for world industry (1974)	Voluntary action by industry
	UNECE	Convention on Long-Range Trans-Boundary Air Pollution (1979)	EC Directive and national executive actions
	UNECE and EEC	ECE Regulation No 15 on gaseous emissions from motor vehicles (regulation 15.04 enters into force 1985)	EC Directive and national regulations
	OECD	Statement on "the polluter pays principle" affects subsidisation and cost assignment for air pollution control	EC recommendation and national executive actions

LEVEL	BODY	SUBJECT	APPLICATION
European Economic Community	EC	Directive 75/716 Sulphur Content of Gas Oil (1975)	National legislation (Control of Pollution Act, 1974) and regulations
		Directive 80/779 Smoke and sulphur dioxide in air (1980)	National legislation (various in UK)
		Directive 78/611 Lead in Petrol (1978)	National regulations (Control of Pollution Act 1974)
		Directive 77/312 Biological Screening of the population for lead (1977)	National Executive Action
		Directive 82/884 Limit value for lead in air (1982)	National Executive Action?
		Directives 70/220. 74/200, 77/102, 78/665, 72/306 and 77/537 Pollutant emission from petrol and diesel engined vehicles (applying ECE Regulations to Community)	National Regulations (in UK under Road Traffic Act 1972)
		Directive on chlorofluorocarbon manufacture	Agreement with industry
		Directive 84/360. Air Pollution from Industrial Plant (1984)	National actions under Control of Pollution Act, Health and Safety legislation and new legislation
		Directive on Quality Standard for Nitrogen Dioxide (1984)	National executive action: application of regulations on vehicle emissions

TABLE 2: CONTRIBUTIONS TO 1980-1983 REDUCTION IN SULPHUR DIOXIDE EMISSIONS

	Million Tonnes
1980 TOTAL EMISSIONS	4.67
Reductions due to lower S content of fuel oil[1]	0.20
Reductions due to fuel switching to gas and nuclear	0.23
Reductions due to energy conservation and industrial restructuring[2]	0.52
1983 TOTAL EMISSIONS	3.72

Notes

1. This assumes the S content of fuel oil did not change between 1982 and 1983.
2. Data do not allow these two sources of decline to be split.

TABLE 3. CONTEMPORARY AIR POLLUTION CONCERNS

POLLUTANT	IMPACT	PROPOSED CONSEQUENCE	SPACE/TIME SCALE
Carbon dioxide (and other "greenhouse gases")	Atmospheric warming.	Changes to hydrological cycle, agricultural pattern, sea level.	Global: Century (for doubling, leading to ca 1.5°C to 3°C global warming).
Chlorofluorocarbons.	Stratospheric ozone depletion.	Increased penetration of UV-B radiation, leading to increased incidence of skin cancer: some contribution also to climatic change.	Global: decades to century.
Sulphur dioxide, nitrogen oxides.	Wet and dry deposition on vegetation, soils, fresh waters and catchments leading to acidification. Deposition on stonework, glass and other artefacts causing corrosion.	Loss of fisheries and changes in aquatic ecosystems; acidification of soils with ionic changes. Loss of irreplaceable historic monuments and damage to recent buildings and materials.	Regional: decades (present phenomena attributed to progressive build up, not swiftly reversible).
Sulphur dioxide, nitrogen oxide, hydrocarbons photochemically produced oxidants including ozone.	Direct damage to plant tissues, enhancing ion (Ca^{2+}, Mg^{2+}) loss through leaching by rain.	Forest damage (34% of stands in Federal Republic of Germany affected) Crops losses (magnitude uncertain).	Regional: Short term direct impacts: also cumulative over decades.
Benzene and other aromatics.	Human health.	Carcinogenesis (especial concern arising over substitution for lead in petrol).	Regional or local: decades.
Lead and other metals.	Human health and accumulation in ecosystems.	Possible long term impacts on ecosystems including those in sea, to which atmosphere is a major dispersion pathway.	Regional or local: decade.

TABLE 4. Topics Treated in Annual State of the Environment Reports

Subject Area	Topic	Year
~~The atmosphere~~	Climatic changes and their causes	1974*,1976,1980
	Possible effects of ozone depletion	
The marine environment	Oceans	1975*
Freshwater environment	Water resources and quality	1974*,1976
	Ground Water	1981
Land environment	Land resources	1974*
	Raw materials	1975*
	Firewood	1977
Food and agriculture	Food shortages, hunger, and losses of agricultural land	1974*,1977,1976
	Use of agricultural and agro-industrial residues	1978
	Resistance to pesticides	1979
Environment and health	Toxic substances and effects	1974*,1976*
	Heavy metals and health	1980
	Cancer	1977
	Malaria	1978
	Schistosomiasis	1979
	Biological effects of ozone depletion	1977
	Chemicals in Food Chain	1981
Energy	Energy conservation	1975*,1978
	Firewood	
Environmental pollution	Toxic substances	1974*
	Chemicals and the environment:	
	-possible effects of ozone depletion	1977
	-chemicals and the environment	1978
	Noise pollution	1979
Man and environment	Human stress and societal tension	1974*
	Outer limits	1975*
	~~Population~~	1975*,1976*
	Tourism and environment	1979
	Transport and the environment	1980
	Environmental effects of military activity	1980
	The child and the environment	1980
Environment management achievements	The approach to management	1974*,1976
	Protection and improvement of the environment	1977
	Legal and institutional arrangement	1976*
	Environmental economics	1981

* Indicates brief treatment in early reports.

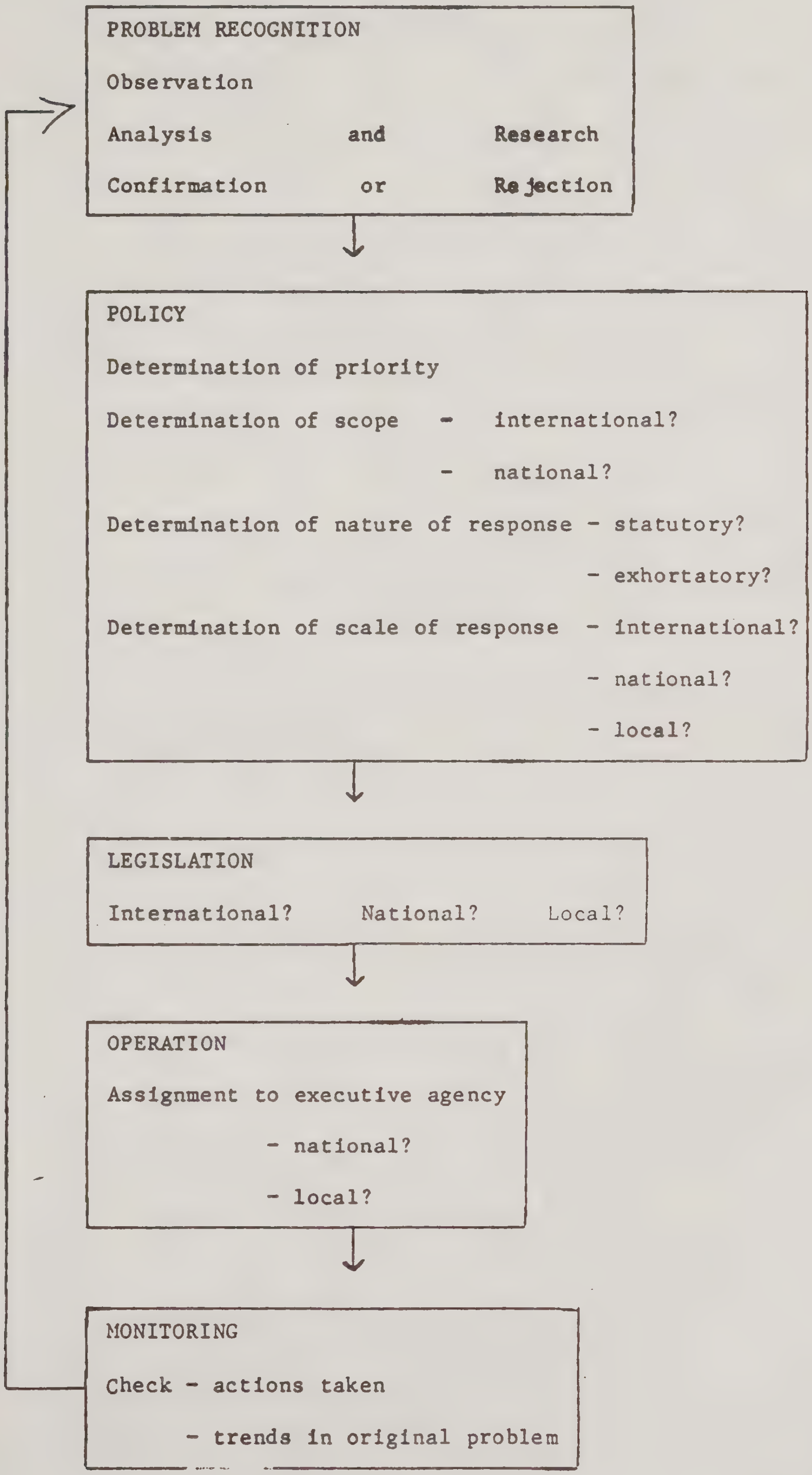
TABLE 5

	PROBLEM STATEMENT	SCIENTIFIC ANALYSIS	ACTION
BEFORE 1950	"Acid rain" first described as consequence of industrial pollution (Manchester 1872). Air pollution recognised as a factor in unsuccessful forestation in industrial South Pennies (Scientific paper in 1908). Acidification related to loss of fish in Scandinavia (several scientific papers in 1920s).	Sporadic publications describing phenomena.	None.
1950 -1970	Atmospheric transport and deposition of nutrients and acids postulated in Scandinavia. First paper indicating significant deposition of UK and Central European sulphate emissions in Scandinavia (1968).	European Air Chemistry Network established in Scandinavia (1956).	None.
1970s -1980	Swedish case study for UN Conference on Human Environment argued that long range transport was causing damage to freshwaters and forests (1972) and called for international action.	OECD Cooperative Programme to measure Long-Range Transport of Air Pollution in Europe (1973-1977) established scale and pan-European nature of phenomenon. Costs and benefits of controls also analysed (OECD; to 1980). First international synoposium on acid precipitation and the forest ecosystem (Oslo, 1972 and Telemark Conferences on the Effects of Acid Precipitation). EMEP system established (1977). Royal Society discussion on Pathways of Pollutants in the Atmosphere (1977).	ECE Convention on Long-Range Trans-Boundary Air Pollution signed (1979).
Since 1980		International Conference on Ecological Impact of Acid Precipitation (Sandefjord, March 1980).	ECE LRTBAP Convention entered into force (1983)

	PROBLEM STATEMENT	SCIENTIFIC ANALYSIS	ACTION
Since 1980 (cont)		Royal Society/Scandinavian Academies joint research programme (funded by CEGB and NCB). Royal Society Discussion meeting on Effects of Deposited Sulphur and Nitrogen Compounds (1983).	First Executive Body adopted statement calling for substantial SO_2 emission abatement (1983). Swedish Conference on Acid Deposition called for urgent action (1982). EC (Karlsruhe) Conference on 'Acid Deposition - a' Challenge for Europe' (1983). Ottawa Conference: 10 nations adopt commitment to 30% reduction in sulphur emissions by 1993 (March 1984): Munich Conference: [14] nations enlisted in "30% Club": 4 Eastern bloc nations agree to cut transfrontier movement by 30%: virtually all EC and ECE nations accept need to reduce emissions. EC Directive on Air Pollution agreed (March 1984.

	PROBLEM STATEMENT	SCIENTIFIC ANALYSIS	ACTION
Since 1980 (cont)			EC Draft Directive on reduction of air pollution from Large Plants and Commission proposals for Directive on motor vehicle emission control considered by Environment Council (June 1984).

FIGURE 1. STEPS IN THE POLICY FORMULATION PROCESS


PROBLEM RECOGNITION
Observation
Analysis and Research
Confirmation or Rejection
POLICY
Determination of priority
Determination of scope - international?
- national?
Determination of nature of response - statutory?
- exhortatory?
Determination of scale of response - international?
- national?
- local?
LEGISLATION
International? National? Local?
OPERATION
Assignment to executive agency
- national?
- local?
MONITORING
Check - actions taken
- trends in original problem

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AIR POLLUTION CONTROL – SITUATION REVIEWS INCINERATORS

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ENGLAND

INTRODUCTION

A few years ago some collected statistics contained the quote "338 incineration plants have to date been constructed in Great Britain, with 295 of these having the refinement of boilers for waste heat recovery". This sounds an ideal demonstration of energy conservation by recycling the heat content of the refuse rather than burying it in tips. (The word "tip" is used rather than the somewhat deceptive modern name of "landfill site"). Unfortunately this exciting news referred to 1914! Some descriptions in old technical journals are of plants in South Wales providing steam to high-speed engines driving DC electric generators to contribute power to local tramway systems. Again Babcock W.1.F. water-tube boilers are described, with handfired grates, supplying heat to adjacent public swimming baths in Glasgow.

Fifty years later the situation had regressed badly. Most of these plants had been scrapped, partly due to reaching the end of their life, partly due to the development of large power stations and the national grid making small local generating stations uneconomic, partly due to the changing nature of refuse as the reduced use of open fires caused a drop in cinder content of refuse; and finally due to rising wage rates affecting the viability of these hand-fired schemes. A number of multi-cell type batch incinerators had been built by local authorities between the two were (and a few in the 1950s) but hardly any of these had any heat recovery systems.

A new wave of interest arose due to Continental and American success in constructing large refuse incineration plants with full heat recovery and reports on their first operating years inspired new enthusiasm.

PRESENT INCINERATION PLANTS

Around 60 incineration plants of the new continuous mechanical grate pattern were built by local authorities in Britain but unfortunately most were considered as "destructors" rather than heat recovery stations. Only a few included boiler plants and quite a number of troubles were experienced with both types. The ones without heat recovery had to cool the gases from the combustion chamber before they were acceptable for high efficiency cleaning plant such as electrostatic precipitators. The water spray cooling tower was developed as an apparently simple device to cool the gases by evaporating water into them, using high-pressure nozzles similar to oil-burner designs to give atomisation. In spite of model testing work the achievement of good spray patterns turned out to be very difficult in practice. The nozzles themselves wore very rapidly compared to identifical designs atomising fuel oil, and the gas flow patterns altered with changing loads so that uniformly cooled exit gases were rarely achieved. Streams of water droplets were often carried through to the precipitators, causing breakdown of the electrical fields, formation of hard deposits on plates and solid layers in dust hoppers which resisted normal "rapping" methods of dislodgment.

Plants fitted with boilers also had troubles: principally, fouling of heating surfaces, where deposits grew rapidly around water-tubes or inside smoke tubes and could not be cleared by normal soot-blowing methods. At least two major plants could only be cured by complete removal of the original boiler systems and replacement by better designs, at very high cost indeed. Many of these problems had already been overcome on earlier Continental plants but solutions were either ignored or "improved upon" in these early British designs. However, either by considerable reconstruction, or by correct design in later units, very good service and availability is at last being obtained from a few units.

Another lesson that was not learned properly when heat recovery was being considered was to find a reliable year-round customer. In Scandinavia, where district heating has been popular for many decades, a simple self balancing system has been practiced for their small towns. The refuse is incinerated to produce low pressure hot water in uncomplicated boilers and this heat is then fed into the district heating mains. If the houses connected for heat are the same houses supplying refuse (i.e. most of the town uses the district heating system) then the incinerator supplies domestic hot water requirements and offsets mains losses. For the months of the year when space heating is needed, additional boilers are successively brought into service and these are fired with conventional fuels. Such systems ensure that the refuse-fired boiler plant (a more purposeful name than "incinerator") runs steadily at normal rated load all year, and yet can be shut down in summer for overhaul since one of the other boilers can take over. Denmark, for example, currently burns 75% of its refuse in such district heating etc. schemes.

REFUSE QUANTITIES AND POSSIBLE ENERGY SAVINGS

Currently, Britain produces around 30 million tonnes of refuse per year, roughly 1 kg per day from each member of the population. This is probably a low estimate since it may not include all the industrial waste, often of high calorific value, which is disposed of by private contractors engaged directly by the firms concerned. Domestic refuse varies in calorific value also, depending on the particular area of the country and the relative income levels of the population. Table I, based on Department of Energy sources, shows a typical analysis. Assuming this is reasonably representative of the country's refuse, then the heat content of 1 tonne of refuse is equivalent to 0.40 tonnes of industrial coal (say 11,300 Btu/lb or 26,300 kJ/kg) or 0.25 tonnes of residential fuel oil (17,800 Btu/lb or 41,400 kJ/kg). Consequently, if we could recover all the heat from this 30 million tonnes of refuse at the same efficiency compared to using coal or oil, we could save some 12 million tonnes of coal or its equivalent in other fuels.

FUTURE POSSIBILITIES

How can the heat content of refuse (both domestic and industrial) be utilised? The following methods are all commercially possible:-

(1) Mass incineration, such as in some local authority

TABLE I TYPICAL COMPOSITION OF DOMESTIC REFUSE

	% by weight	Average Calorific Value kJ/kg	Contribution to Calorific Value - kJ
Fine dust	13	9600	1248
Paper and board	27	14600	3942
Vegetables, Putrescible Matter	28	6700	1876
Textiles	3	16300	489
Plastic	5	37000	1850
Glass	8	nil	-
Metals	8	nil	-
Remainder (wood, leather, etc.)	8	17600	1408
Cumulative Calorific Value of refuse - kJ/kg:-			10813

NOTES

Water content can vary very widely dependent on weather conditions, and degree of protection while in domestic bins, the collection vehicle and in reception storage at the collection site. Values up to 49% have been recorded in very wet weather which can make the refuse very difficult to burn or pulverise to very small size.

incinerators, in which the material is burned in bulk using mechanical grate actions to progress the material through a contribution chamber and give continuous ash removal. The heat can produce high pressure superheated steam for electricity generation, or combined heat and power, or alternatively low pressure or hot water for sale to industrial or commercial users or for district heating. A variation on this to improve the size distribution and improve uniformity of combustion on the grate is to carry out a coarse pulverisation to break up large items such as cardboard boxes and large cans. Volume is considerably reduced by mass incineration, by up to 95% after ferrous metal recovery, with a weight reduction of 75%.

(2) Smaller incinerator plant burning untreated waste, or industrial waste of rather high calorific value, often of the recently developed two-stage combustion type in which the primary combustion takes place with less than stoichiometric air needs followed by a secondary combustion chamber in which volatiles are burned and excess air added to control gas temperatures prior to waste heat boilers. The recovered heat is usually used directly for industrial process/heating. Similar volume and weight reductions occur as in (1).

(3) Upgrading of refuse to remove certain relatively incombustible material, generally the heavier items such as metals, glass, solid wood, etc., and by air classification to produce a higher calorific value portion, mainly paper, board, plastic, textiles and some of the lighter wood and dry vegetable matter. This third method can be sub-divided dependent on the degree of treatment and proportion of the original refuse that is discarded, i.e.

a) Pulverisation, removal of ferrous metal and some contraries such as fine dust, giving from 65% to 80% by weight of the original refuse. One use is then to inject it into cement kilns, requiring pulverisation down to approx. 20 mm. The cement kiln already operates at high temperature to destroy toxic and noxious gases and already has highly efficient dust collection equipment. Limited replacement of coal is possible, typical figures being 10% by heat value but greater quantities risk deterioration in cement quality. The incombustible material in the refuse becomes incorporated in the kiln clinker production, and sulphur or chlorine from the refuse is neutralised by the limestone in the raw consituents added to the kiln. Another use is in combined firing with solid fuel in large water tube boilers such as by the "I.M.I. method" involving blowing the refuse into the combustion chamber above the bed of burning coal. Examples are at I.M.I., Birmingham and Courtaulds, Grimsby.

b) Pulverisation, ferrous metal extraction and classification by ballistic or air current methods to give a considerably enhanced calorific value and almost complete elimination of glass, aluminium and other heavier fractions. There is a relationship between the percentage by weight of refuse in the separated portion and calorific value. To obtain high calorific values of around 16000 kJ/kg only about 30 to 35% by weight of the refuse is so recycled. If a higher proportion is used, say 40%, there is a deterioration in calorific value down to possibly 14000 kJ/kg. It is important to remember that the majority of the refuse is rejected after having considerable work done on it and still has to be disposed of at landfill sites and that only about half the total heat content of the original refuse is recycled. The enriched fuel is either burned as a "flock" on selected combustion equipment or is considerably compressed into pellets or small briquettes which are easier to transport and store. Plants to produce pelletised enriched waste have been constructed at Eastbourne, Doncaster and Newcastle and others are under consideration.

EXAMPLES OF HEAT RECOVERY FROM MASS INCINERATION PLANTS

Edmonton, still the largest incineration plant in Britain,

TABLE II COMPARISON OF PELLETISED W.D.F. WITH COAL

	W.D.F.	COAL
Typical pellet diameter	15-20 mm	-
Typical pellet length	40-50 mm	-
Moisture content as delivered, approx %	14	7
Ash content (on dry solids basis) %	12 to 16	6 to 7
Sulphur content (on dry solids basis) %	0.4	1.5
Chloride content (on dry solids basis) %	0.6	0.3
Volatile matter (on dry solids basis) %	65	35
Fixed carbon (on dry solids basis) %	10	53
Typical gross calorific value kJ/kg		
as delivered a) good quality	15,500)	28,100
b) poorer quality	14,000)	
Present price as delivered per tonne	?	£56
Density as delivered kg/m^3	600	1400

is currently operating at a disposal cost around £10.50 per tonne of input refuse after crediting the sales of electricity generated and other minor payments such as ferrous scrap (the market for this has largely collapsed in recent years due to reduced steel production - the cost of separation and baling is barely covered by income for the scrap, although there are some environmental advantages in not placing this ferrous material on land-fill sites). Edmonton had very bad publicity in its earlier years due to frequent shut downs and rapid boiler fouling and indeed was out of commission in whole or in part for about a year while extensive modifications were made, but for many years now it has been a very reliable plant contributing up to 25MW of electrical power to the national system. This operating cost is lower than most of the other disposal methods in the GLC area.

At Sheffield, a refuse-fired boiler plant consisting of two 10 tonnes per hour firing systems provides part of the heat requirements for a district heating scheme of high density multi storey flats. This scheme was already in existence before the new heat station was built. For the year 80/81 published operating figures show:

Plant availability (% of year)	98%
Refuse throughout	93,973 tonnes
Ash taken to landfill as top cover	36,581 tonnes
Ferrous metal recovered	808 tonnes
Operating costs (capital charges and running costs)	£1.34 million (£14.26 per tonne)
Actual nett costs after credits for income from heat sales due to fuel saved on normal boilers, scrap sales etc.	£0.41 million (£4.46 per tonne)

Heat recovered paid for 69% of the running costs. Indeed a slightly better performance could have been obtained if more refuse had been available, as the plant only operated up to the availability of refuse within the collecting area. There was spare capacity available at times when the original boiler plant was still using conventional fuel to meet heat demands.

SMALLER HEAT STATIONS

There are some advantages in encouraging industrial firms with year round heat loads to install refuse-fired boilers either using refuse from local authority collections or their own (and neighbours') industrial waste.

a) An industrialist has taxation advantages on depreciation and capital allowances (although these will diminish each year due to the 1984 budget) and may also be eligible for Regional Development and other Government grants.
b) Such a firm has maintenance staff, workshops, etc. already on site and a modestly sized incineration plant does not create any major problems.
c) Industrialists already are familiar with control of labour on shift systems and already have amenities such as toilets, washrooms, canteens, wage-paying and timekeeping facilitites and can provide security staff or watchmen to cover shut-down periods. A local authority usually has to create all these facilities when building an incinerator.

d) Such a firm may have easier access to leasing or finance facilities to eliminate the problem of finding capital.

Several firms are now offering small furnaces into which refuse can be charged by automatic ram and in which there is a primary chamber where the material is oxidised and volatiles driven off, but combustion of the volatiles and products of combustion such as carbon monoxide is completed in a second chamber where extra air is added. Oil or gas burners are fitted to preheat both chambers at start-up and also to maintain sufficiently high temperatures when, for any reason, the refuse quality is too poor. Several manufacturers now offer these, with various configurations and features. The first ones installed in this country were batch types in which the ash built up within could be removed at the end of the shift, often after allowing the refractory primary chamber to cool. Later developments have included feed rams with optional longer reach, so that ash can be moved to the back of the chamber, either for manual removal through a rear door or for discharge into some form of ash conveyor. Larger units are now available with multiple hearths and automatic rams to move the burning mass along from one hearth to the next and eventually to the ash chute. These can operate continuously.

These units are factory assembled rather than being built on site and current practice is to install several units rather than a single large one. Tests on grit and dust emissions from these units have shown that the two-stage combustion process gives much less carry-over in the gases than the large mechanical grate incinerators, so that far less fouling and deposits occur in the waste heat boilers, and chimney emissions can be below Second Working Party recommended levels, with quite simple cyclone collectors at boiler exits or, in some favourable cases, without need for any arrestor.

A variation on this theme of two-stage combustion is to use the waste burning furnaces as hot gas generators, leading these gases into the combustion chamber of a water-tube boiler, which also acts as the secondary burning zone. This boiler can then be fired with a conventional fuel, such as coal, using a chain grate stoker forming the floor of the combustion chamber.

There should always be a facility to dump gases before the boiler to enable steam/hot water output to be reduced in case of sudden drops in demand, using a dump stack with its own refractory lining.

Examples are:-
Norprint Limited of Boston, who burn 29 tonnes/week of their own waste on a single furnace with waste-heat boiler, installed in 1980. The nett annual saving is £45,900 compared to burning conventional fuel on the existing factory boiler, paying back the capital cost in just under two years. The plant is operated on a daily cycle, feeding in waste during the day and allowing the furnace to burn down overnight so that ashes can be removed early next morning prior to re-starting waste firing.

Fords of Dagenham produce about 300/325 tonnes of waste per week with an average calorific value of 18,210 kJ/kg (7,830 Btu/lb). Two two stage furnaces are being installed, fed by rams from loading hoppers. Ash is discharged continuously via a water seal and conveyor into disposal skips. Lorries bring waste from various parts of the site to a storage pit, from which a grab crane feeds the hoppers. The two furnaces will operate continuously five days per week and feed hot combustion products to a waste heat boiler which provides around 14,000 kg/h steam at 17 bar (31,000 lbs/h at 250 psig) into the works main steam distribution. The overall cost, inclusive of civil and building work, is just over £1m and the project is being assisted by a grant under the ETSU Demonstration Project Scheme.

If the marginal cost of this steam is taken as £3.50 per 1,000 lbs (i.e. fuel saving only on main boilers) then annual saving should be £650,000.

Andersons of Manchester have installed a single two stage furnace to burn 900 kg/h (2,000 lb/h) of factory waste, using a loading conveyor and hydraulic ram loader. Heat is recovered by passing the gases through one set of smoke tubes, in a special composite boiler, and the furnace tube is fired with a fuel oil/natural gas dual-fuel burner to generate extra steam beyond that available from the waste, or to meet the total factory demand if the waste-burning furnace is out of action. The boiler can generate up to 5,000 kg/h (11,000 lb/h) of steam on the waste side alone, or 6,800 kg/h (15,000 lb/h) on the fired side alone. The firm state that the capital cost will be recovered in two to three years.

If the director of a commercial or industrial firm is to be persuaded to purchase heat from an incineration plant, he will expect to see some profit. He will argue that he has to retain his existing boiler plant on a "care and maintenance" basis in case of emergency. Alternatively his steam requirements may exceed what can be made available from the incinerator so that he may have to continue operating his boiler plant on a reduced load and he will then claim that his labour, maintenance and capital charges are not significantly reduced. In either case he will say that the advantages to him are really limited to the cost of fuel that he would not now burn. He will certainly not abandon his own boiler plant as he will want its "insurance" value. Let us assume a "target" price of selling heat as being 70% of the fuel cost of generating the same output therm. Table III shows that for medium to large plants in three-shift operation this "target" price in 1984 could be 35, 29 and 21 pence per delivered therm for oil, gas and coal-fired plants respectively. (It also demonstrates that there is still a financial argument for converting existing oil and gas-fired plants to coal where the plant is in good condition with reasonable remaining life and there are no peculiar conversion problems.)

GAS COOLING

If the waste gases are to be cleaned efficiently, then

TABLE III COST OF GENERATING HEAT WITH CONVENTIONAL FUELS

	Fuel Oil		Natural Gas		Coal	
Price of fuel delivered to site i.e. pence per delivered gross therm.	£154/tonne 38.0		31p/therm 31.0		£56/tonne 21.0	
Rate of increase in fuel price in last 12 months	9 to 11%		2%		6%	
Operating Cost/therm of useful output (in pence)	(a)	(b)	(a)	(b)	(a)	(b)
Labour, maintenance, administration and capital charges.	17	9	16	9	22	13
Fuel cost, including storage and preheating where applicable	59	50	48	41	33	30
Total cost of heat per output therm.	76	59	64	50	55	43
Target selling price at 70% of fuel cost.	41	35	34	29	23	21

they must be cooled since multiple cyclone arrestors and electrostatic precipitators both have limiting temperatures. Multiple cyclones can be constructed to operate at high temperatures, say 700°C if heat-resisting steels are used, but of course the cost is increased, and more usual materials limit the gas temperatures to around 450°C.

An electrostatic precipitator has the same materials limitation and also the collecting effect is hampered at high temperatures, so that manufacturers prefer entering gases to be at 250-300°C.

With a refractory-lined incinerator, the gas temperature will be 900-1,100°C leaving the combustion chamber, so that considerable cooling is necessary. In this country it seems that the electrostatic precipitator will be used for the larger plants of say 3 tonnes/hour upwards.

The usual method for the fairly large incinerators discussed, comprises spraying water at high pressure through atomising nozzles into the gases, usually in separate cooling towers. Although this is cheaper than adding large volumes of additional cold air, it is by no means cheap if town water is used. The water evaporated into the gases increases their volume and as an electrostatic precipitator is designed for low gas velocities past its plates, this increase in volume automatically increases the size and cost of the

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NOTES FOR TABLE 111

1. For each fuel the costs of generating steam in a boiler plant are shown divided into two columns: (a) is for a small plant operating under single shift conditions with reduced Summer load, i.e. much of the load is space heating; (b) is for a medium to large plant operating on loads of 50 to 90% of boiler ratings on a three shift basis.

2. Fuel prices are taken as at April 1984 (see EURA Comparison of Energy Costs).

precipitator. This is not the end, because the induced draught fan and the chimney diameter also have to be increased in size and cost to deal with the extra gases.

If a boiler plant is installed, then this cools the gases without adding to their mass; the cooling tower and water spray equipment is no longer needed, and the precipitator, induced draught fan and chimney diameter can all be reduced. It will be a lucky coincidence if all the heat from the boiler can always be used. Normally the customers have a variable demand, sometimes smaller than the boiler output. However, this can be catered for, and the best way to have a plant with a flexible output of heat is to install a cooler consisting of finned tubing over which air is blown, rather like a very large unit heater as used in factories for space heating. Surplus heat can then be dissipated through this cooler, and providing the amount of heat that has to be wasted is not too great a proportion of the total produced in that year, the scheme can still be very attractive. One rather interesting Scandinavian plant is known where a boiler is fitted and all the output is then passed through a cooler. It was considered by the designers that in their particular circumstances this gave a more compact plant with lower running costs compared to one with a water spray cooling tower.

A third possible method of cooling the gases is to admit extra cold air after the furnace to bring the temperature down, and a fourth is to use the heat in the gases to evaporate water from sewage sludges to dry them prior to incineration. However, it is outside the scope of this paper to consider this latter. Certainly there is some argument that if the gases are cooled down to 300°C by this method, objectionable volatile gases and breakdown products from the drying sludge are not decomposed.

Considering the first three methods of cooling:-

(a) Assuming a well built plant with little or no inleakage of air, the use of a boiler plant does not increase the mass of the products of combustion and their volume remains the same.

(b) A conditioning system to cool the gases by spraying water into them requires 500 gallons (2.3 m^3) of water per tonne of refuse. The mass of the gases is increased by this water and the volume increases approx. 1.46 times. This increases the size, capital and running costs of all items downstream, particularly the precipitator, induced draught fan and chimney. The power needed to handle this extra volume will also be greater.

(c) Air dilution cooling would increase gas volume and mass to 4.3 times (a) above and is impractical for all but small incinerators.

It is this increase in volume and mass of the gases without a boiler plant that helps the financial case; the cost of the boiler, pipework, pumps and fan coolers is compensated by elimination of the water-spray conditions, pumps, emergency system and savings on precipitator, fan and chimney.

RESTRICTION OF PARTICULATE EMISSIONS

The 1956 Act requires "any practicable means" to be used to minimise grit and dust emissions and requires grit arresting plant to be installed on all new plant burning pulverised fuel, and on new plant burning other solid matter at the rate of one tonne or more per hour. A Working Party Report of 1967 (18) recommended levels of permissible emission in relation to furnaces burning fuel equivalent to 100 lbs (45.45 kg) of coal or more per hour for plant where the emissions were only from the fuels used, with no contribution from any material being heat heated. This Report was accepted and the permissible emission levels were set out in the publication "Grit and Dust" of 1967 (20) which were at first only guidelines for local authorities. However, Regulations (11 and 12) in 1971 give legal effect to these levels and to a method of measurement. There was an initial period of exemption for existing plant but this has long since expired. These Regulations tabulate the quantity of grit and dust which may be emitted, using two Schedules, the first for "furnaces" rated by heat output, such as boilers or air heaters, and the second for "furnaces" rated by heat input such as metal treatment furnaces. In each Schedule a much lower emission level is set for liquid fuel fired furnaces than for solid fuel. The 1971 Regulations did not apply to incinerators or to furnaces where the material being heated contributed to the emissions.

A second Working Party reported in 1974 (19) on possible permissible levels of emission under Section 2 of the 1968 Act in relation to incinerators and to furnaces where the material being heated contributes to the emission.

The members benefitted from a large number of tests on such plant that were carried out, 1962 - 1964, by NIFES as a study commissioned by the Department of Environment. In effect this Report covered all the remaining types of plant not included in the 1967 Report.

Surprisingly, action to convert this Report's recommendations into legal standards of emission has dragged on without result to date. A Draft Regulation was issued in 1977 (16) to local authorities and other interested parties, but it has never been re-issued as any legal Regulation under the Act. The current position is that intending installers of new plant are referred to the diagrams in the 1974 Report and the equivalent tables in the 1977 Draft and told that it will be advisable to meet these levels. NIFES can give no better guidance than this.

SAMPLING/TESTS OF PARTICULATE EMISSIONS

Regulations of 1968 (5) enabled a local authority to require an occupier to provide suitable sampling points, access methods and sampling platforms if needed, to his chimney or furnace flues to permit the use of measuring equipment to determine emission levels. One of the methods described in BS 3405 (25) was to be used and the sizes of sampling points and their positions were also to be in accordance with the BS. Six weeks' notice had to be given. This Regulation then went on to require the occupier, having provided sampling points, on receiving not less than 28 days' written notice, to make and record such measurements in accordance with the methods described in "Measurement of Solids in Flue Gases" (26) and to report the results within 14 days of the tests to the local authority. Full details of initial selection of sampling points and the testing procedure to be used is given in BS 3405 (25) and Hawksleys's book (26) and it is not intended to duplicate the very lengthy material contained in these. However, certain practical points and problems are worth emphasising.

There is not much point in local authorities asking for, or in firms carrying out, expensive measurements of grit and dust emission rates if the plant is badly operated or poorly maintained. The use of the wrong fuel, or inefficient combustion (particularly the use of excessive air quantities) can easily double the weight of solids emitted and regular checks on plant operation may well reduce the chance of complaints and may prevent any instruction to measure the emission.

EQUIPMENT AND ACCURACY

The majority of tests are carried out using the BCURA (the old "British Coal Utilisation Research Association") cyclone/filter equipment, which has been marketed since 1957 so that over 25 years experience of its use has accumulated. This uses a small cyclone which collects a flue gas sample through a sharp edged inlet nozzle and separates the majority of the grit and dust, which passes into a detachable hopper which can be weighed before and after test. Any very fine dust passes on to a back-up filter system which removes most of this fine material.

Other equipments suitable for tests under BS 3405 are

a) The Mark III A probe, developed by the Central Electricity Generating Board, which essentially consists of a head assembly, inserted into the gas stream, which contains a filter bag or thimble. For boiler and furnace work a glass fabric filter bag is usually used. Care must be taken on installations burning fuels with a sulphur content where there is a likelihood of SO_3 formation which would attack ordinary glass fibre. Silica fabric or mat filters must be used in such cases. (The BCURA filter is always packed with silica, borosilicate or quartz wool fibre for this same reason).

b) The cyclone probe developed by the National Coal Board. This is not manufactured commercially but details can be obtained from the NCB where firms are confident of their own ability to make up a set of this equipment. Relatively few of these are in use.

BS 3405 states that measurements of emissions taken in accordance with the laid-down procedure will have an accuracy of ± 25% and BS 893 states that with the much lengthier procedure accuracy will be ± 10%. However, it must be remembered that their accuracy statements are defining the extremes, when due to bad luck, all the possible causes of error such as velocity measurements, weighing samples before and after, turbulence, drying etc., combine in one direction and are all at the estimated maximum error. In most cases errors compensate one another and also increased experience of operators can reduce the size of individual errors so that results will normally be closer to the correct value than implied by the ± 25% or ± 10%. A series of size analyses, coupled with the emission figures, will be invaluable in enabling a consultant to advise on new or improved collectors and in enabling manufacturers to quote, and give performance guarantees.

ACTS, REGULATIONS, ORDERS AND OTHER PUBLICATIONS AVAILABLE FROM HER MAJESTY'S STATIONERY OFFICE

1. The Clean Air Act 1956
2. The Clean Air Act 1968
3. The Control of Pollution Act 1974
4. The Health and Safety at Work Act 1974

5. The Clean Air (Measurement of Grit and Dust) Regulations 1968 SI 1968 No. 431
6. The Clean Air (Arrestment Plant) (Exemption) Regulations 1969 SI 1969 No. 1262
7. The Clean Air (Emission of Dark Smoke) (Exemption) Regulations 1969
8. The Clean Air (Heights of Chimneys) (Prescribed Form) Regulations 1969 SI 1969 No. 412
9. The Clean Air (Heights of Chimneys) (Exemption) Regulations 1969 SI 1969 No. 411
10. The Clean Air (Authorised Fuels) Regulations 1956, 1963, 1965, 1970 (No. 2), 1971, (No. 3), 1971 (No. 4) et seq
11. The Clean Air (Measurement of Grit and Dust) Regulations 1971 SI 1971 No. 161
12. The Clean Air (Emission of Grit and Dust) Regulations 1971 SI 1971 No. 162

14. Smoke Control Areas (Exempted Fireplaces) Orders 1970 et seq.
15. The Dark Smoke (Permitted Periods) Regulations 1958 SI 1958 No. 498
16. Draft Regulation - Emission of Grit and Dust from Furnaces 1977.
    Issued by Department of the Environment 27 May 1977. Ref NPCA/366/1. (sets out likely future emission requirements for furnaces, incinerators and driers as recommended by the Second Working Party, using appendices 1 to 4 of their Report (see item 19).
    Not on sale but most local authorities have copies which may be inspected.

17. The Fifth Report of the Royal Commission on Environmental Pollution "Air Pollution – An Integrated Approach"
18. Report of the Working Party on Grit and Dust Emissions 1967
19. Report of the Second Working Party on Grit and Dust Emissions 1974
20. Grit and Dust – The measurement of emissions from boiler and furnace chimneys Standard levels of emission 1967.
21. Chimney Heights – (Second Edition) 1967 – A Memorandum.

OTHER PUBLICATIONS

23. BS 2742C The Ringelmann Chart 1957)
24. BS 1742M The Miniature Smoke Chart 1960) British
25. BS 3405: 1983 Measurement of) Standards
Particulate Emissions including Grit) Institution
and Dust (simplified method))

26. Measurement of Solids in Flue Gases (2nd Edition) 1977 Hawksley et al. Institute of Fuel.

(Note. There is no number 13)

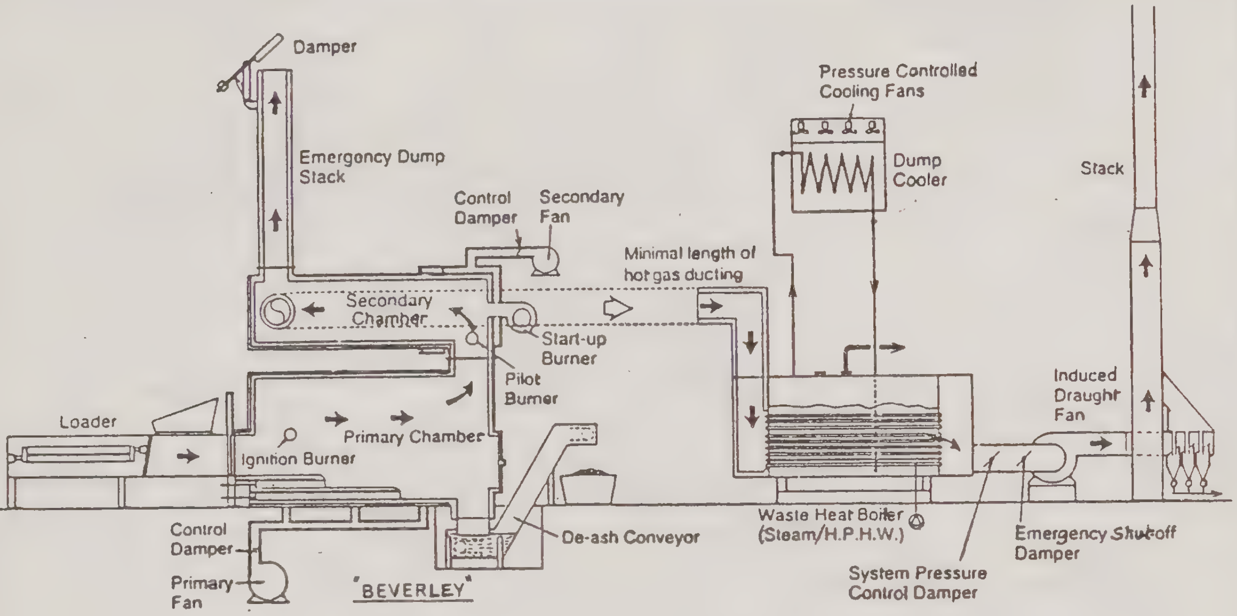

FIG.1

TWO TYPES OF MODERN INCINERATORS

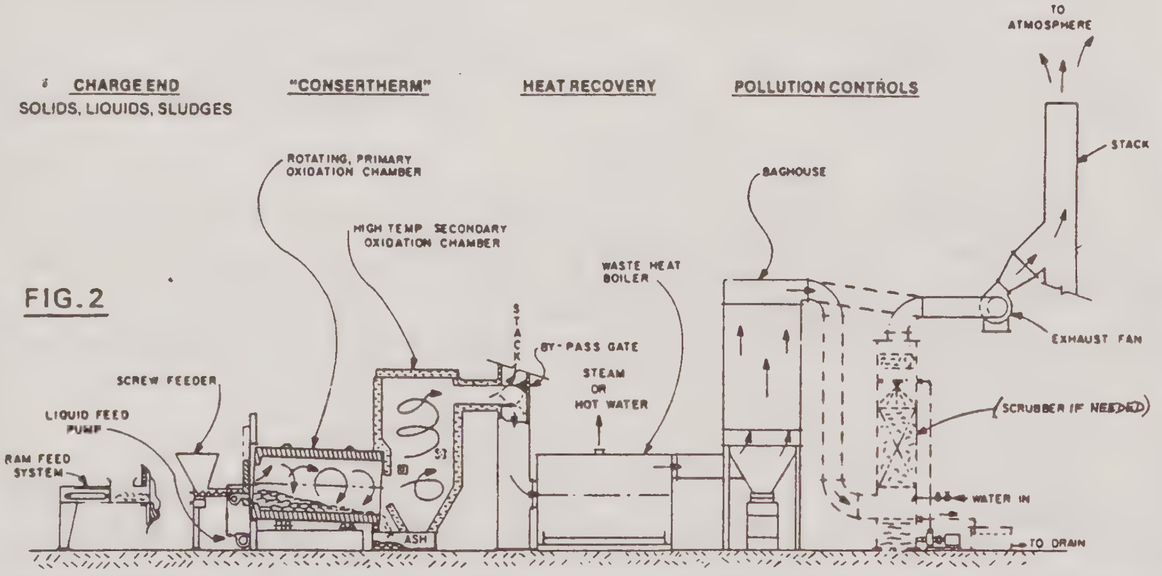

FIG.2

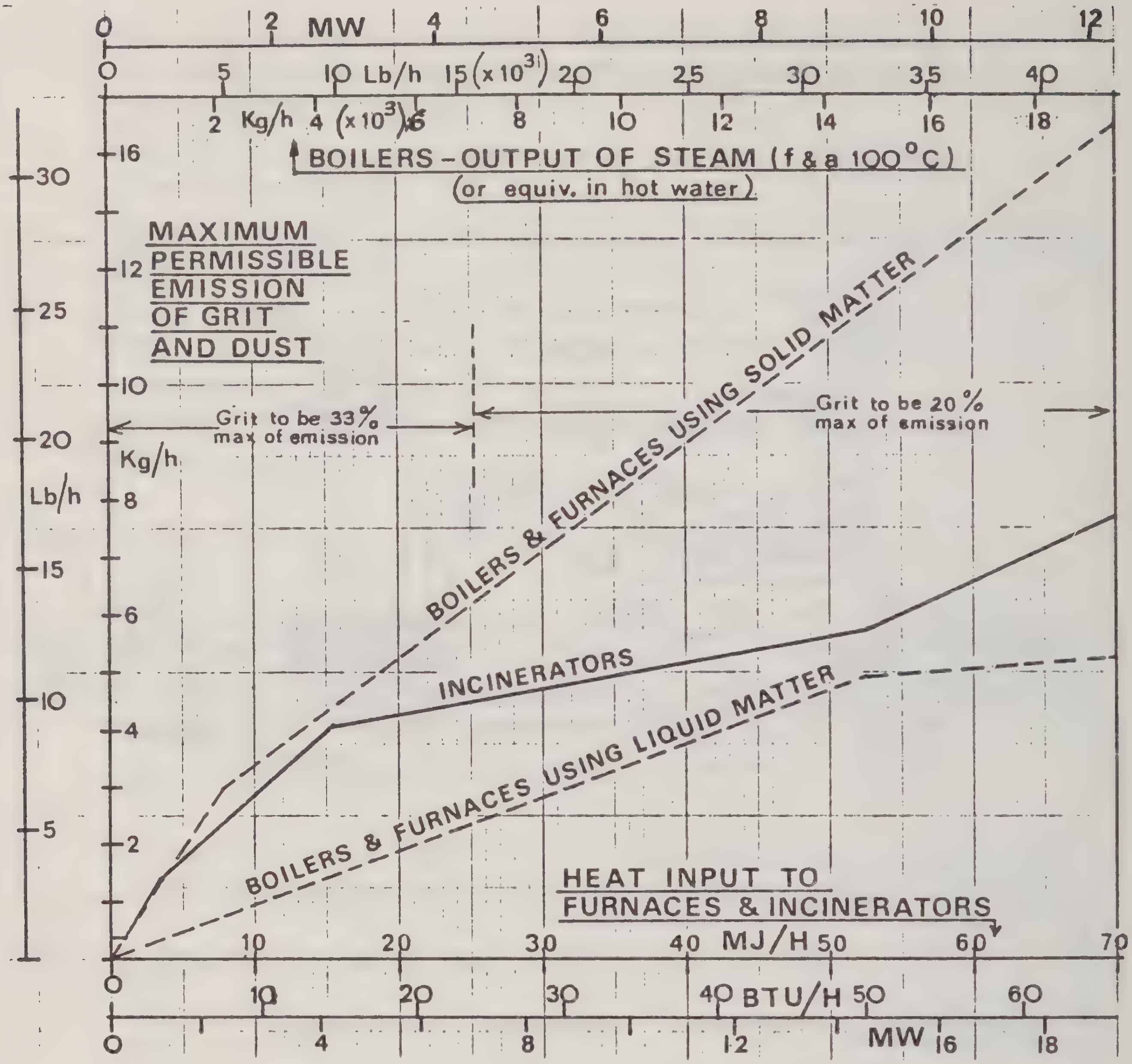

Diagram showing maximum permissible emission levels of grit and dust from boilers, incinerators and furnaces (the furnace lines on the diagram are for those types in which the material being heated does NOT contribute to the emission.)

The incinerator line is constructed from the Report of the Second Working Party and the Draft Regulation of 1977.

Use the correct horizontal axis - remember furnaces and incinerators are assessed by heat input of fuel etc. going into them, but boilers by steam output (or equivalent hot water or thermal fluid heat gain).

nsca

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INDOOR AIR POLLUTION AND ITS IMPLICATIONS FOR HUMAN HEALTH

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INTRODUCTION

The growing interest in indoor air pollution in recent years has been influenced by several events and developments. In the past research focused mainly on the effects on health of outdoor air pollution. However, as outdoor levels of pollution, measured usually in terms of smoke and sulphur dioxide (SO_2) in the UK, declined (Weatherley et al., 1976) the association between respiratory illness and high levels of these pollutants began to disappear. With the removal of one of the main factors which contributed to the aetiology of respiratory disease in western industrialised countries, other factors which could be involved in the development of the disease may be more readily detected than in the past.

Alongside this improvement in the outdoor environment certain changes have also taken place indoors which independently have enhanced our concern about the indoor environment. Rapid development in the chemical industry has brought exposure to many new man-made substances found in a variety of consumer products, furnishings and building materials. The trend to conserve energy indoors has led to the use of various insulation methods and reduction in ventilation which may in turn cause increased levels of pollution indoors. Similarly artificial ventilation may under certain conditions enhance the spread of pollutants indoors.

A further reason for growing interest in the indoor environment is the improvement of tools which are needed for the detection and monitoring of pollutants. Thus investigations of the effects on health of certain pollutants in the general population which would have been impractical in the past are now becoming more feasible.

Not only the home but offices, schools, transport and public meeting places should be considered when reviewing the indoor environment because each location will present a different set of conditions under which pollutants might become harmful to health. In addition the indoor environment and its range of pollutants will vary between countries. Several organisations have reviewed the problem of indoor air pollution. The World Health Organization convened a working group which first described the general aspects of indoor air pollution, its sources and components (WHO, 1979) and then reviewed current knowledge about these pollutants indoors and their relation to various air quality criteria and standards (WHO, 1983). Most criteria and standards are directed towards the outdoor environment but as people may well be exposed to higher levels of certain pollutants indoors than outdoors it would seem important to consider both environments when discussing air quality. For most pollutants indoors there is a dearth of information about the distribution of levels to which the population is being exposed. Until such information becomes available it will be difficult to assess fully the impact that this pollution may be having on health. Appropriately, WHO in collaboration with the United Nations Environmental Programme have published a guide to estimating human exposure to air pollution (WHO, 1982). This provides information about the contribution that both the indoor and outdoor environments make to human exposure, the sources of pollution, methods of measurement and examples of the type of levels which may be found indoors.

A list of pollutants which may be found indoors, their potential effect on health and their sources are summarized in Table 1. Preventive action is already being taken to remove exposure to asbestos and reduce high levels of carbon monoxide indoors. For the other pollutants, however, there remains insufficient information about levels found indoors and their likely effects on health. Our own experience investigating the effects on health from nitrogen dioxide (NO_2) in the home illustrates the problems which this type of research faces and the gaps in present knowledge.

RESEARCH INTO NITROGEN DIOXIDE INDOOR AIR POLLUTION

In a national study of school children living in England

and Scotland an association was reported between the prevalence of respiratory illness and use of gas for cooking in the home (Melia et al, 1977). The association seemed to be independent of socio-economic factors such as social class and other characteristics of the home. Further analysis of another group of children from the same study also showed an association between respiratory illness and gas cooking (Melia et al, 1979). As the gas cooker is an unflued gas appliance which emits a variety of pollutants it was suggested that indoor air pollution might be the cause of the association. NO_2 seemed to be one of the most suspect pollutants because of its known effects at high concentrations on man and animals.

About the time that this hypothesis was being proposed a small personal sampler for NO_2 became available which was highly suitable for use in surveys (Palmes et al, 1976). The sampler has several advantages over the more sophisticated instruments such as the chemiluminescent monitor as it requires no pump or electrical supply; it is easy to use and highly portable. Its main disadvantage is that while it provides accurate measurements over periods ranging from a few hours to several days it does not provide measurements of short-term peak levels which are characteristic of emissions from gas cookers. Nevertheless using the personal monitor several researchers have shown marked contrast in average levels of NO_2 between homes where electricity is used for cooking and homes where gas is used for cooking. Some results are summarised in Table II.

The association between respiratory illness and gas cooking did not provide direct evidence that indoor air pollution from NO_2 is harmful to health. The relation between respiratory illness and NO_2 needed to be investigated in a specially designed survey. Two studies have now been conducted in England. In the first study (Florey et al, 1979) several negative results were found. There was no relation between lung function in primary school children and levels of NO_2 in the home, or between the prevalence of respiratory illness and weekly average levels of NO_2 in kitchens. However, within homes where gas was used for cooking a positive association was found between respiratory illness and weekly average levels of NO_2 in the children's bedrooms (Table III). The second study (Melia *et al*, 1982) was conducted to test whether this one positive finding was repeatable and to investigate other aspects of the home environment. We were unable to find a relation between the prevalence of respiratory illness and levels of NO_2 in children's bedrooms. However there was some suggestion that respiratory illness might be associated with high levels of NO_2 in the living-rooms of the children's homes, although this result was not statistically significant (p .10, Table IV).

The lack of consistent or statistically significant results from these studies seems to indicate that if a positive association does truly exist between respiratory illness and levels of NO_2 inside homes where gas is used for cooking the association is likely to be weak and difficult to detect in small groups of children. It is possible that a stronger association might be found in other sections of the population. Infants and the elderly, for example, who have a high prevalence of respiratory illness and may spend more time indoors than school children, may be particularly susceptible to the effects of NO_2. It is also possible that if the measurement of exposure to NO_2 could be improved to monitor peak levels on a large scale effects on health might more readily be detected. As other pollutants arise in the emissions of gas combustion these should perhaps be monitored as well as NO_2. Investigation of these aspects of the problem await development of suitable monitoring equipment.

The relation between respiratory illness and gas cooking has been investigated in several other populations, mainly in the USA, but with mixed results (Lutz *et al*, 1974; Speizer *et al*, 1980). More recently in the UK no relation has been found between respiratory illness and gas cooking in two groups of infants (Melia *et al*, 1983; Florey, personal communication, 1984). Thus results for the effects on health from gas cooking and NO_2 in the home do not seem to be consistent.

In summary, research into most indoor air pollutants and their effects on health is still in its early stages of development. The studies of gas cooking and NO_2 illustrate some of the difficulties which have to be faced when investigating effects on health from certain pollutants. These include limitations in our methods for measuring pollution. Passive samplers need to be developed for various pollutants to make large scale monitoring practical and suitable instruments for monitoring peak as well as average levels are required. Our measures of health also need to become more sensitive, particularly as some effects on health from indoor pollution are likely to be small, at least, in comparison with the effects on health previously found for outdoor air pollution and tobacco smoking. For small effects on health larger numbers of people need to be studied which once again requires practical inexpensive methods of measurement.

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TABLE I

Examples of indoor air pollutants, their potential effects on health and their sources

Pollutant	Health effects	Sources
Asbestos	Carcinogenic effects and respiratory disease	Fire-retardant insulation
Allergens	Irritation of respiratory system	House dust, animal dander
Carbon monoxide	Carboxyhaemoglobin poisoning	Fuel burning, tobacco smoke
Carbon dioxide	Systemic interference	Metabolic activity, combustion
Formaldehyde	Irritant to eyes and airways, carcinogenic and systemic effects	Particle board, insulation, furnishings, tobacco smoke
Mineral and synthetic fibres	Irritant to airways skin and mucous membranes	Acoustic, thermal and electric insulation
Nitric oxide and nitrogen dioxide	Effects on respiratory system	Fuel burning, tobacco smoke
Organic substances	An irritant and systemic effects	Adhesives, cooking, cosmetics, solvents
Ozone	Irritant to airways and systemic effects	Equipment with electric arcing and ultraviolet light sources
Radon	Carcinogenic effects	Building materials, water
Suspended particulate matter	Irritant to airways	Combustion products including tobacco smoke
Water vapour	Allergy arising from promotion of mould growth, possible enhancer of droplet infection leading to respiratory disease	Biological activity, combustion, evaporation

TABLE II

Weekly average levels of NO_2 (ppb) measured in the winter by type of fuel used for cooking and room in home. (Florey *et al*, 1979)

ROOM IN HOME		COOKING FUEL	
		Electricity	Gas
Kitchen	mean	18.0	112.2
	SD	2.4	2.7
	range	6-188	5-317
	number	87	428
Bedroom	mean	13.9	30.5
	SD	2.0	2.6
	range	3-37	4-169
	number	18	107

TABLE III

The frequency (%) of one or more respiratory conditions in boys and girls from homes where only gas was used for cooking grouped according to the weekly average level of NO_2 in the children's bedrooms (ppb). (Total number of children given in brackets)
(Florey *et al*, 1979)

	Gas cooking homes: level of NO_2 (ppb)		
SEX	4-19	20-39	40-169
Boys	43 (23)	58 (19)	69 (13)
Girls	44 (25)	60 (15)	75 (8)

TABLE IV

The frequency (%) of one or more respiratory conditions in boys or girls from home where only gas was used for cooking by the weekly average level of NO_2 in their living room. (Total number of children given in brackets.)
(Melia *et al*, 1982)

SEX	Level of living room NO_2 (ppb)			Total
	25	25-49.9	50	
Boys	55 (22)	66 (50)	69 (29)	64 (101)
Girls	25 (20)	56 (48)	58 (19)	49 (87)

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TRENDS IN ACIDIFICATION OF PRECIPITATION IN THE UK AND WESTERN EUROPE

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ABSTRACT

A major reason for studying trends of deposition of sulphate and nitrate over time is to determine the relation between emissions and deposition. The longest series of data are those of the European Air Chemistry Network (EACN). Analysis of these has so far produced disappointingly few results. It is suggested that in the analysis more use should be made of calculations of deposition by models of deposition. It is hoped that present and future monitoring networks will avoid the problems of the EACN results.

1. INTRODUCTION

In this paper we shall be concerned not only with acidity as such, i.e. hydrogen ions, but also with the other major ions - if only because hydrogen ions are not themselves emitted and the acidity is the result of an equilibrium with the other ions.

There are a number of reasons why we should be interested in time trends in the ions in precipitation. Some of them relate to the interpretation of the effects produced (or thought to be produced) but these are not the concern of this paper. Our principal concern is with the relation between emissions and deposition. Because emissions have changed over time, a study of trends in deposition can provide information on the likely effects of changing emissions in the future. This is of obvious use in formulating emission policies aimed at reductions in deposition.

We shall now briefly consider why deposition of sulphate and nitrate may not follow emissions of the oxides of sulphur and nitrogen. Possible reasons include:

a) Changes over time in the weather patterns which lead to deposition, particularly in the frequency with which precipitating air masses have passed over the various source regions. The effects of this and other forms of meteorological variability can be reduced by averaging over several years or by using a long enough period (usually taken to be a minimum of about 10 years) of observations. This will not eliminate longer term changes in climate which may very well exist and are very hard to deal with.

b) Existence of a 'background' contribution to deposition at least in areas near the Atlantic coast. Studies of the sources of pollution based on analysis of back trajectories have always found an 'undecided' contribution which cannot be attributed to any region in the area studied. This contribution may be due to: emissions in Europe which occurred before the start time of the trajectories; to very long range transport, e.g. from North America; or to non-industrial emissions. If a significant contribution is non-industrial, which would not be expected to move in parallel with industrial emissions, the observed trend in deposition would be altered.

c) Deposition may not be proportional to rates of emission. This suggestion of "non-linearity", as it is commonly called (though 'non-proportionality' is a better term) has been much discussed since the proposal of Rodhe et al. (1981) that the rate of conversion of SO_2 to H_2SO_4 in precipitation is indirectly influenced by emissions of NO_x (by competition for the chemical species assumed responsible for the oxidation). A good recent discussion of the process is contained in the 1983 report on acid deposition in North America by the National Research Council.

For policy purposes 'non-linearity' is clearly significant. (The National Research Council concluded, however, that the evidence was against its being very important in Eastern North America).

2. TRENDS IN EMISSIONS

The data in this section come from Barrett et al. (1983) which should be consulted for further details.

Fig. 1 indicates the trend in man-made emissions of sulphur dioxide in the United Kingdom from 1850 to 1980. The emissions can be seen to reach a maximum in the late 1960s and to decline after 1970. A similar graph for Europe is not at present available but Table 1 gives some figures for a number of European countries. The table shows that different parts of Europe do not reach a maximum at the same time. It is clear that at sites mainly influenced by UK emissions a linear trend over time is not to be expected in deposition between, for example, 1950 and 1980. It is also clear that the expected trends in deposition at European sites will depend on the major sources of the sulphate that they receive.

Fig. 2 gives estimates of changes in NO_x emission between 1905 and 1980 for the United Kingdom. No corresponding data seem to exist for other European countries but the differences from sulphur dioxide are apparent. The trends in nitrate deposition would be expected, therefore, to be different from those of sulphate.

3. MEASUREMENTS IN PRECIPITATION

Although there are earlier measurements, extending over more than a century, the major data base is the European Air Chemistry Network (EACN) established in the 1950s and, after 1971, the WMO BAPMoN network. Few sites continued in operation over the whole period (and these are mostly in Scandinavia) and there are problems with the quality of the data produced. Nevertheless, they form the longest set of continuous measurements in existence and a number of analyses of them have been made.

The first essential in any analysis is to screen the data so that, as far as possible, unreliable data are eliminated. Although other criteria have sometimes been employed, the main approach (after trying to ensure that the sites themselves were adequate and unchanged over the period) has been to attend to the charge balance reported - i.e. is there equality of the positive and negative ions reported. Such a procedure, when applied to the UK sites of the EACN by Allam and Tuck (see Barrett et al., 1983) eliminated so many data that it is difficult to draw any conclusions for the UK. (This exercise also showed that the original protocols for the EACN network were not sufficiently stringent!) Granat (1978) analysed non-marine sulphate and found that in Scandinavia over a 20-year period, the deposition appeared, very broadly, to rise in parallel with the increase in emissions of Europe as a whole. (This conclusion appears in the text of the paper but not in the abstract; this has led to some confusion.) Few conclusions could be drawn outside Scandinavia where the records are much shorter in length. It is believed that Granat has carried out further analyses which are shortly to be published, so further comment does not seem worthwhile at present.

The most detailed study is that of Kallend et al. (1983). These authors were mainly concerned with concentration, not deposition. The analysis was based on linear regression of concentration on time. Although such a linear trend analysis is useful for many purposes, it is not necessarily the best approach from the point of view of this paper, which is concerned with the relation between deposition and emission. In addition to the regression analysis, however, Kallend et al. note that "the main feature of the hydrogen ion data .. (is) .. that the concentrations measured in the 1970s are higher (typically a factor of 3 or 4) than the concentrations measured in the 1950s. More substantial increases are seen for nitrate and a less marked increase for sulphate."

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There must be a feeling of disappointment that relatively little has emerged from this large scale investigation extending over such a long period and it seems to the present author that additional efforts should be made to obtain information from the data. Two lines of approach are suggested. Screening of the data included could be extended. For example, Benarie and Detrie (1978) noticed that the correlation of H^+ and SO_4^{2-} in the data from an OECD exercise was very variable - which indicates local effects; Kallend et al. showed that considerable differences exist in a group of 4 stations within about 25 km of one another. Efforts to remove noise due to local influence seem, therefore, to be well worth making.

On a different level comparison of observed trends with those predicted from models are to be encouraged. The only work of this kind known to the author is in Fisher (1983) who used a statistical model to estimate wet deposition patterns of sulphate for 1950 and 1975, using published estimates of SO_2 emissions from European countries. In much of Europe he calculated changes so small that they would be difficult to detect from measurements, but larger increases in some areas. In southern Scandinavia he calculated an increase of nearly a factor of 2, in broad agreement with observations. This approach seems one that should be extended.

CONCLUSIONS

1. The study of trends in deposition over time in conjunction with emission is capable of giving valuable information.

2. Analysis of the data set covering the longest period, the European Air Chemistry Network, has so far produced rather little information. It seems desirable to attempt to carry the analysis further.

3. In particular, the use of modelling techniques on the emission data is likely to be a very useful approach.

4. Future monitoring networks should learn from the experience of EACN and attempt to avoid the problems found with those data.

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TABLE 1

Examples of Annual European SO_2 Emissions (as sulphur, million tonnes)

	1950	1972	1980
Czechoslovakia	0.50	1.43	1.55
France	0.86	1.30	1.60
German Democratic Republic	1.56	2.74	2.00
German Federal Republic	1.36	2.10	1.79
Norway	0.02	0.09	0.07
Sweden	0.09	0.46	0.22
United Kingdom	2.60	3.26	2.34
Europe (excluding Soviet Union)	9.99	18.35	19.98

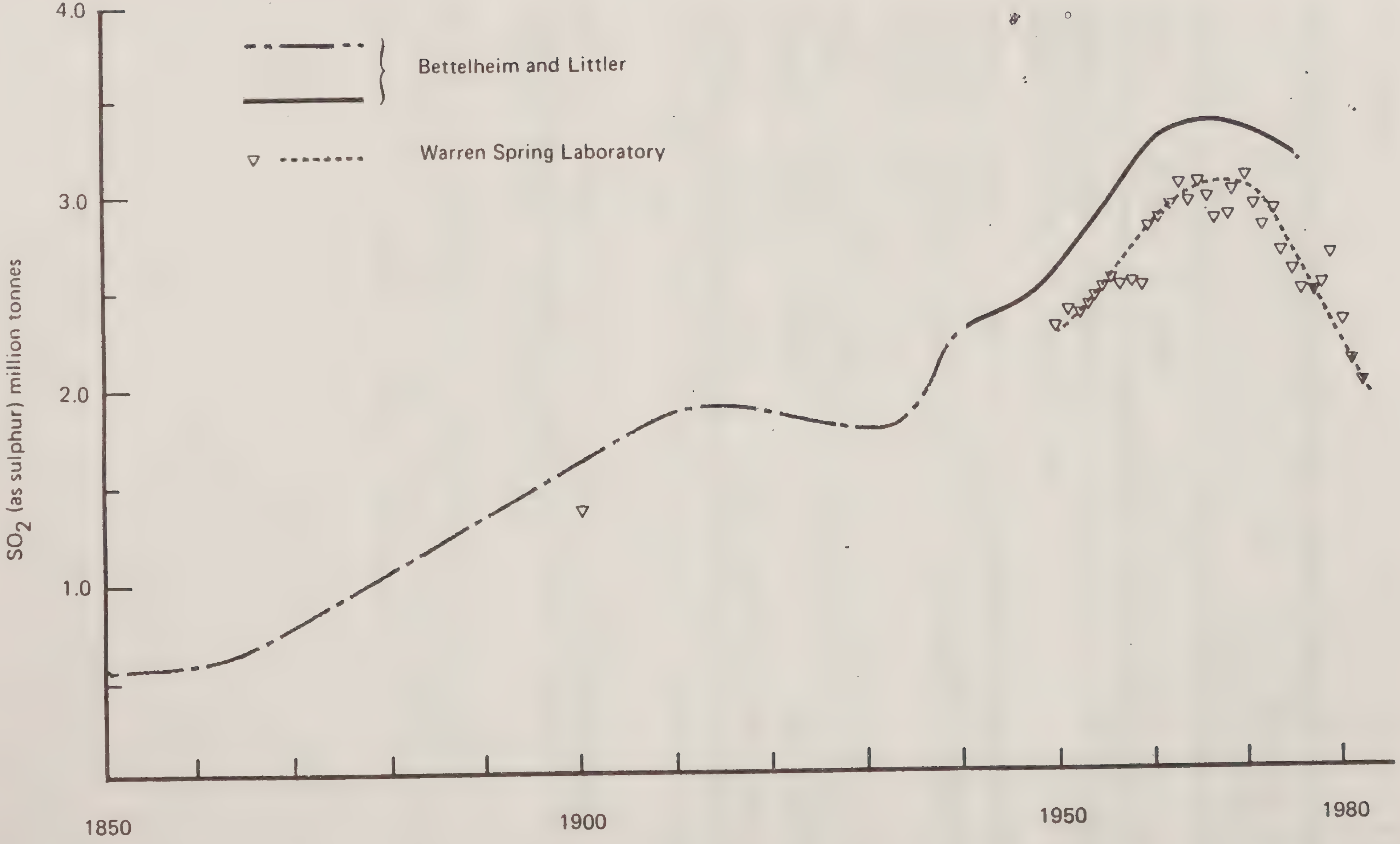

Figure 1 Sulphur dioxide emissions in the United Kingdom from 1850.

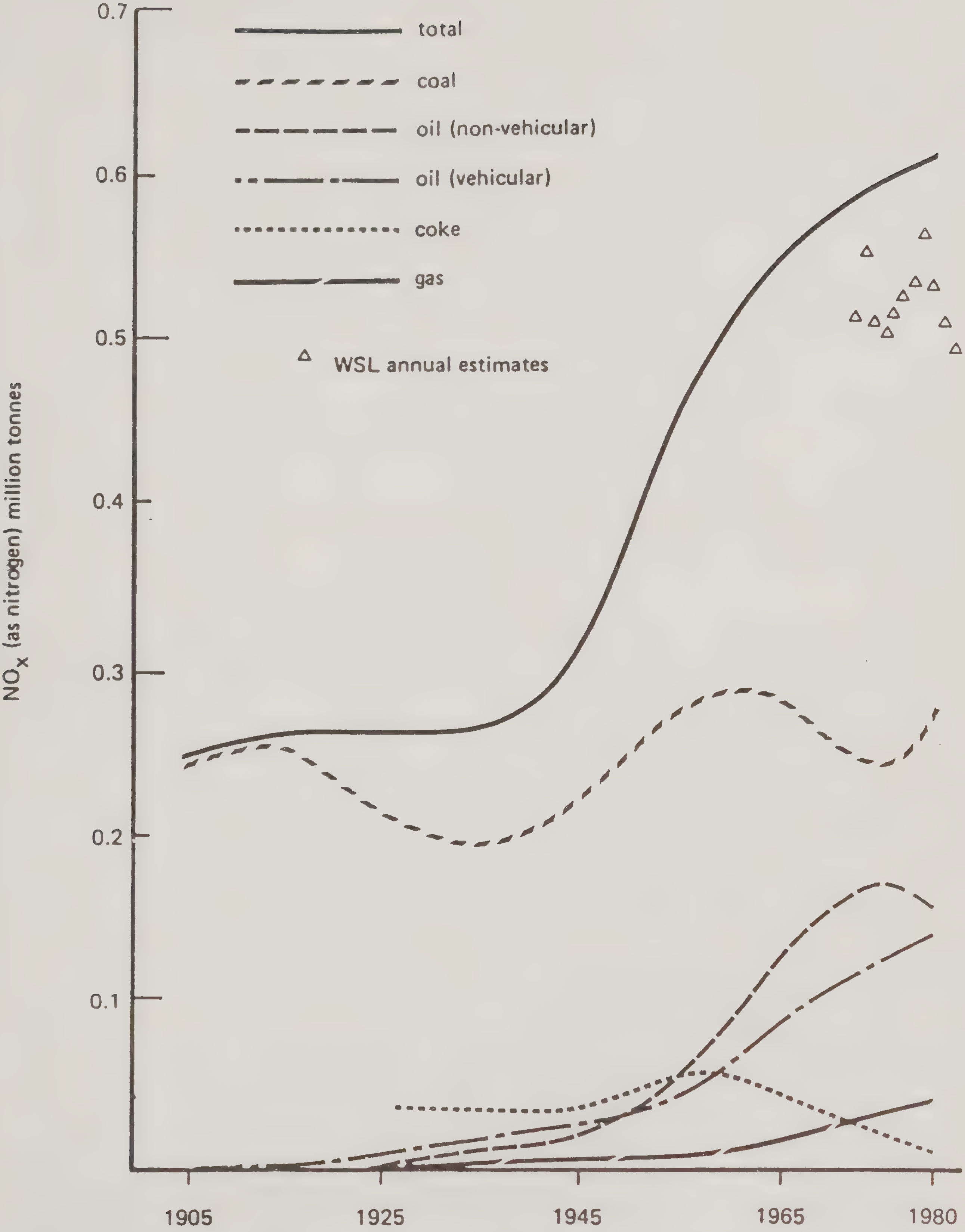

Figure 2 NO_x emissions in the United Kingdom from 1905.

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OZONE FORMATION AND NATIONAL TRENDS

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INTRODUCTION

The presence of ozone in air at ground level was recognised quite soon after the discovery of ozone in the middle of the last century. It was detected by its strong oxidising effect and became associated with clean 'healthy' air, particularly at the seaside. Towards the end of the nineteenth century spectroscopic observations in the atmosphere revealed that ozone is present at about 25 km altitude in much higher abundance than near the earth's surface. It was also recognised that the strong absorption by ozone in the ultraviolet region provided a vital filter preventing harmful solar ultraviolet radiation reaching the earth's surface. Subsequently a great deal of interest in stratospheric ozone developed and has continued to this day.

Some of the ozone formed in the stratosphere is transported into the lower regions of the atmosphere and ultimately to the ground. Thus ozone is a natural component of clean air, the amount depending on location, season and other meteorological factors. The fact that ozone concentrations could become high in polluted air was first discovered in Southern California during studies of air pollution in the Los Angeles area in the late 1940s. The term 'photochemical smog' was used to describe the phenomena resulting from the action of strong sunlight on polluted air in the Los Angeles basin, i.e. reduction in visibility and the formation of ozone and other oxidising species. Subsequently, research by Haagen-Smit and co-workers(1) in the 1950s showed that ozone formation occurs by photochemical reactions in the atmosphere involving nitrogen oxides and unburned hydrocarbons, originating from motor vehicle emissions and other combustion and industrial sources. Since ozone is formed from reactions of primary pollutants in the atmosphere it is termed a secondary pollutant.

In the 1960s it became apparent that the ozone problem was not confined to the Los Angeles area but could be detected in other North American cities. It is now recognised that photochemical ozone is a widespread phenomenon in the developed world, the symptoms appearing when meteorological conditions are favourable in the USA, Europe, Japan, Australia and South America(2).

The most economically important effects of photochemical ozone are on agricultural crops and other vegetation. The smogs of Southern California eliminated citrus fruit growing in the Los Angeles basin, and damage to numerous tree species and a variety of crops are well documented. The loss of crop value due to damage by elevated ozone in the United States has been assessed at three billion dollars(3). Recently it has been suggested that ozone damage may be an important factor in forest dieback in the Federal Republic of Germany(4), which is at the centre of current debate regarding acid deposition.

Ozone at the levels encountered in pollution episodes has demonstrable deleterious effects on human health, particularly on respiratory function. This has been highlighted recently in concern for athletes competing in the Olympic Games in Los Angeles. Other photochemical oxidants such as peroxyacetylnitrate (PAN) are thought to be responsible for the eye irritation characteristic of severe smog episodes. A visually impressive effect of photochemical air pollution is the formation of intense haze, which can reduce visibility to a few hundred metres on warm sunny days, in severe smog episodes. It was this aspect which prompted the Harwell studies of photochemical pollution in England about 12 years ago(5).

FORMATION OF ATMOSPHERIC OZONE

In order to understand the formation of ozone it is necessary to examine the complex chemistry which occurs in the atmosphere. This chemistry involves the trace gaseous components which undergo a series of elementary gas phase reactions, promoted by the absorption of solar radiation by certain key species. The reactions provide an oxidative scavenging mechanism for trace constituents, natural and man made, which are emitted into the atmosphere.

Ozone is formed by the combination reaction of atomic oxygen with molecular oxygen, in the presence of any other gas molecule M

$$O + O_2 + M \quad O_3 + M$$

which is required to carry away some of the energy released in forming the ozone. In the upper atmosphere the atomic oxygen, O, is produced by photodissociation of O_2 by radiation in the deep ultraviolet. Radiation present in the lower atmosphere has insufficient energy to dissociate molecular oxygen and the main source of atomic oxygen here is the near ultraviolet photodissociation of nitrogen dioxide

$$NO_2 + \text{light} \quad NO + O$$

Nitrogen dioxide is formed from nitric oxide which is a product of combustion, and which is one of the primary pollutants necessary for photochemical ozone formation. The other necessary primary pollutants are hydrocarbons and to see the connection we need to examine the chemistry of the nitrogen oxide-ozone system in a little more detail. The following reactions occur rapidly in a sunlit atmosphere

$$\begin{array}{ll} NO_2 + \text{light} & NO + O \\ O + O_2 + M & O_3 + M \\ NO + O_3 & NO_2 + O_2 \end{array}$$

The overall effect is no net chemical change but if some other reaction converts NO to NO_2 without using up an ozone molecule a net production of ozone occurs e.g.

$$\begin{array}{rl} NO + XO_2 & NO_2 + XO \\ NO_2 + \text{light} & NO + O \\ X + O_2 & XO_2 \\ O + O_2 & O_3 \\ \hline \text{net } X + 2O_2 & XO + O_3 \end{array}$$

The role of X is played by the free radicals formed in the oxidative breakdown of hydrocarbons and other organic compounds, which occurs by the attack of hydroxyl radicals, OH, on the hydrocarbon molecules, XH, e.g.

$$OH + XH \quad H_2O + X$$

The hydroxyl radicals themselves are produced by photochemical processes involving ozone, hydrogen peroxide and other trace gases and it follows that the whole process of hydrocarbon oxidation and ozone formation is accelerated by strong sunlight.

It should be emphasised that the concentration of ozone prevailing in the surface atmosphere is a balance between input from the upper air, production by local photochemistry, and removal by chemical and physical sinks. The most important physical sink is absorbtion and destruction at the ground. This process is termed dry deposition and it causes ozone concentrations near the ground to fall when downward mixing and photochemical production of ozone are retarded, such as at night-time.

MEASUREMENT OF ATMOSPHERIC OZONE

Experience has shown that our knowledge of the behaviour of a particular atmospheric pollutant is largely determined by the availability of good methods for measurement of that pollutant. Measurement of ozone in ground level air in the past relied on measurement of the oxidising properties, by passing air through reagents such as iodide solutions and determination of the amount of iodine liberated either colorimetrically or electrochemically. The term 'total oxidant' was employed in early smog studies to describe the amount of ozone and other oxidising species determined by this test. Unless precautions are taken to remove them, reducing agents such as sulphur dioxide produce negative interference in this measurement.

Chemical methods of measurement of ozone have now been largely superseded by more specific physico-chemical methods which can be operated on a continuous basis. The chemiluminescence technique in which ozone is measured by detection of the light emission resulting from its gas phase reaction with ethylene, offers a relatively simple, sensitive, and specific method. Careful attention needs to be paid to the calibration of such instruments, however. The U.V. photometric technique, in which ozone is measured by absorption in its strong U.V. band near 250 nanometers, is the most accurate and easily standardised method. With modern electronic detection and control excellent sensitivity and reliability can be achieved.

OBSERVATIONS OF OZONE IN THE SURFACE ATMOSPHERE

Measurements of ozone concentrations in the surface atmosphere on a routine basis have been conducted in a wide range of localities ranging from urban locations to remote marine and high altitude weather stations. The complex pattern of diurnal, seasonal and spatial behaviour has been well documented and many interpretive discussions of ozone behaviour have been presented. For the purposes of discussion of ozone in relation to photochemical pollution, we are interested in the behaviour in typical inland urban and rural situations in areas where people live. In this case ozone concentration in the surface layer averaged over a period, shows a diurnal variation reaching a maximum in early afternoon and a minimum in the early morning hours. These correspond to maxima and minima in the average mixing depth of the boundary layer, and reflect the fact that ozone is naturally present in the free troposphere and is destroyed at the ground.

The daily maximum concentration of ozone also shows a seasonal variation which follows seasonal changes in the amount of ozone in the free atmosphere. In the Northern Hemisphere mid-latitudes a maximum occurs in spring and a minimum in late autumn. Typical daily maxima in spring might be 40-50 ppb and in late autumn 20-30 ppb. In summertime in populated areas it is often observed that the amplitude of the diurnal variation increases and if daily maxima become in excess of 80 ppb it is generally accepted as indicative of photochemical pollution. Furthermore the maximum tends to be shifted to later in the afternoon as photochemistry dominates over purely physical processes. In severe photochemical smog episodes experienced in southern California or Tokyo, ozone concentrations up to 400 ppb may occur. In Europe the maximum values recorded are about 250 ppb. These episodes are always associated with warm, sunny stable weather and are often accompanied by severe haziness.

The diurnal variation in ground level ozone in polluted air reflects temporal variation in mixing phenomena, primary pollutant emission patterns and insolation. During morning hours mixing is restricted and pollutants build up in the lower air layers. As the sun heats up the air near the ground, vertical exchange is initiated bringing down ozone from the free atmosphere. At the same time photochemical reactions occur producing ozone *in situ* from the nitrogen oxides and hydrocarbons accumulated in the surface layers. Both these effects lead to the increase in the ozone observed during the day. The maximum is reached when the sink processes locally balance the supply of ozone from chemistry and mixing, and as insolation declines in the evening ozone concentration in the surface layer falls, often quite sharply.

Meteorology is a major factor in the occurrence of summertime photo-oxidant formation and when weather conditions are suitable elevated ozone concentrations can be observed over large regions. Furthermore, specific studies have demonstrated the long range transport of photochemical ozone in polluted air masses. For example close correlations have been observed between elevated ozone concentrations and certain polluted air mass tracers such as chlorofluoromethanes at a site in the far west of the Republic of Eire(6). Trajectory analysis showed that these air masses originated over populated areas of Europe.

The travel times of polluted air masses in long range transport cover several days and nights, and the transported ozone resides aloft, in air that is isolated from the ground at night-time due to the temperature inversion. Furthermore primary pollutants from more than one source region can be involved. The range of hydrocarbon pollutants have different 'reactivity', i.e. some species degrade more rapidly and produce ozone more quickly than others. Thus less reactive precursors may be transported further and produce ozone some distance from the source.

Figure 2 shows the behaviour of ground level ozone at a number of sites in South-East England during a warm sunny day in July 1982. These measurements were made on an ongoing collaborative programme sponsored partly by the EEC(7). The wind was in a south-easterly trajectory and the development of high ozone levels over the whole area can readily be seen. This pattern is fairly typical for a photochemical episode, and can be rationalised by a picture involving incorporation of primary pollutants from the London area, into air of continental origin, which already contains elevated and unreacted hydrocarbon and NO_x precursors. The highest ozone levels were reached downwind of London, as has been consistently observed in this programme, on both easterly and westerly trajectories.

TRENDS IN OZONE POLLUTION IN THE UK AND ELSEWHERE

The fact that ozone is a natural constituent of the atmosphere and its behaviour generally is subject to meteorological and seasonal variables, requires that perception of trends in its abundance requires an extended, continuous data base. Such a data base is available for the total atmospheric ozone column, from measurements started in Oxford in the 1930s, but since most of the ozone resides in the stratosphere this gives no information about ozone near the ground or in polluted air. There have been no long term systematic measurements of ozone in surface air in the UK but there has been a record of photochemical pollution episodes at a number of locations during the past decade.

The first suggestion that photochemical air pollution might occur in the UK appears to be based on measurements made at Harwell in 1971(5). The following year surveys were initiated in Central London by the Warren Spring Laboratory and also by the GLC Scientific Branch, which has subsequently accumulated a fairly complete data base for summertime ozone concentration in the capital, based on measurements in both central and suburban areas. The Warren Spring Group have also monitored ozone regularly at Stevenage since 1973 and a number of rural sites have been operated since this time including Harwell, Ascot (Imperial College) and Lancaster (University of Lancaster). Phytotoxicity due to ozone in the British Isles has also been monitored using indicator plants(8).

A summary of elevated ozone levels in the south of England during the period 1972-1983 is shown in Figure 3. The GLC data is taken from a recent review of air pollution in London(9) and shows the number of days on which the GLC guideline value for ozone concentration (160 ug m^{-3} or 82 ppb) was exceeded in each year based on summertime (April-October) measurements. The Warren Spring data, published by the Department of the Environment(10), shows the 99th percentile for ozone measured off-street in Central London i.e. the concentration below which 99% of all observed values lie. Some of the important episodes particularly in 1976 were missed in this survey. The third data set on Figure 3 was obtained from measurements at several rural and semi rural sites, compiled for a recent OECD workshop on the effects of ozone(11). The values are for the number of days on which ozone exceeded 100 ppb during the months April-September inclusive.

It will be seen from Figure 3 that all three data sets, although not directly comparable, show a consistent pattern with generally higher incidence of ozone in the early 1970s, followed by six summers of relatively infrequent incidences of photochemical pollution. There is a large variation in the number of days on which the concentration exceeded guideline levels, but the guideline was exceeded on more than 10 percent of the days in London in only 2 of the 12 summers. Similar statistics emerge for the rural and semi rural ozone.

Comparison with climatic data shows that high concentrations were, as would be expected, more frequent in the sunniest and warmest summers, in particular in 1975 and 1976. The cooler, wetter summers towards the end of the decade showed rather infrequent increases of ozone to the 100 ppb level.

It should be emphasised that the measurements on which the data in Figure 3 are based are not a complete record. In view of the spatial, temporal and meteorological factors which influence ozone concentration, it is not possible from the available UK data to draw any conclusion as to whether or not the ozone burden of the atmosphere over the UK has changed over the last 10 years or over a longer period. Continuous ozone measurements over an extended period at carefully chosen sites and using standardised techniques are required for the detection of such trends.

There are a number of indications from studies elsewhere in Europe that average ozone concentrations may be increasing. A paper has been published on long term measurements of ground level ozone carried out by the Meteorological Service of the German Democratic Republic(12). Daily measurements of ozone were made at 6 hourly intervals using the iodide method at seven stations in East Germany, established in the years 1952-1956. A statistical analysis showed an increasing trend in the annual means of ground level ozone at all stations from the beginning of the measurements up to 1977. Smoothed data for one rural station on the Baltic coast are shown in Figure 4. The annual means were found to be distinctly influenced by the predominant meteorological conditions during the summer months (in the same way that the occurrence of high ozone levels in the UK is influenced), but a lower rate of increase in ozone was also observed in winter. The observed increase seemed to be a large scale phenomenon and the authors suggest a photochemical source resulting from increased emissions of hydrocarbon and NO_x pollutants.

Data obtained at the Hohenpeissenburg Observatory in the southern Federal Republic of Germany since 1971 also seems to indicate an increase in the average ozone concentration both at the ground and at higher altitudes(13). The latter observation is consistent with a report from the United States(14) that there has been a 20 per cent increase in the ozone concentration in the 2-8 km altitude band at mid latitudes in the Northern hemisphere from 1970-1980. This is based on satellite data for global ozone distribution and vertical profile measurements. Whether or not these apparent widespread changes in ozone are of climatological origin or are due to photochemical pollution has not yet been resolved, and remains an important problem in atmospheric chemistry today.

TRENDS IN OTHER POLLUTANTS RELATED TO OZONE FORMATION

In addition to ozone it is of interest to examine data for other secondary pollutants which may be related to photochemical pollution, in a search for possible trends. The association of haze with photochemical pollution has already been mentioned. This phenomenon is due to the presence of light scattering particles in the atmosphere and it has been established that reduction in visibility during fine dry weather is caused mainly by the ammonium sulphate and ammonium nitrate component of the atmospheric aerosol. These salts are formed by the reaction of ammonia with the oxidation products of sulphur dioxide and nitrogen dioxide i.e. sulphuric acid and nitric acid. This oxidation can occur by reaction of hydroxyl radicals (i.e. the same species responsible for oxidation of hydrocarbons and ozone formation) with SO_2 and NO_2. Thus oxidation is accelerated under the conditions favourable for ozone formation and the light scattering particulate burden of the atmosphere increases.

Long term data for the concentration of nitrate and sulphate have been obtained from air particulate samples collected at Harwell since the mid-1950s. Smoothed data are illustrated in Figure 5. They show a small average annual increase in sulphate during the summer (1 per cent per year) with an equal decrease in winter giving zero average annual trend. Nitrate exhibits an average annual increase of 3.5 per cent per year, the rate of increase in summer being approximately double the winter rate. These trends show no apparent direct relationship with emission patterns of the primary pollutants sulphur dioxide and nitrogen oxides but can be rationalised in terms of an increased intensity of photochemically driven oxidation of the primary pollutants. This could result from increased emissions of hydrocarbons together with nitrogen oxides and would be expected to result in an increase in ozone production from the photochemical reactions. These results are therefore entirely consistent with the trends in average ozone observed in Germany.

SUMMARY AND CONCLUSIONS

Although ozone is a natural constituent of the atmosphere its concentration can increase in ground level air due to photochemical reactions involving other pollutants, namely nitrogen oxides and hydrocarbons. The chemical basis of photochemical ozone formation is now quite well understood as a result of intense research in the USA and Europe over the last two decades.

Observations have shown that photochemical ozone formation is a widespread phenomenon in Europe including the UK, when favourable meteorological conditions prevail, i.e. warm, sunny, anticyclonic weather. In these pollution episodes ozone concentrations frequently exceed the guideline levels above which significant deleterious effects of ozone and related pollutants can be detected.

The data base for ground level ozone in the UK is insufficient to detect any long term trends in average ozone concentration, but there are indications from trends in nitrate and sulphate aerosol concentrations that photochemical activity has increased in the air over the UK in the last 30 years.

Systematic measurements of ozone elsewhere, particularly in Germany, show strong indications that average ground level ozone concentrations have been increasing since the early 1950s. It is suggested that this increase may be due to increased emissions of hydrocarbon and NO_x primary pollutants. However, it is uncertain whether this factor alone can account for the changes, since the overall burden of the troposphere in Northern Hemisphere mid-latitudes also appears to have increased and climatic factors could therefore also be involved.

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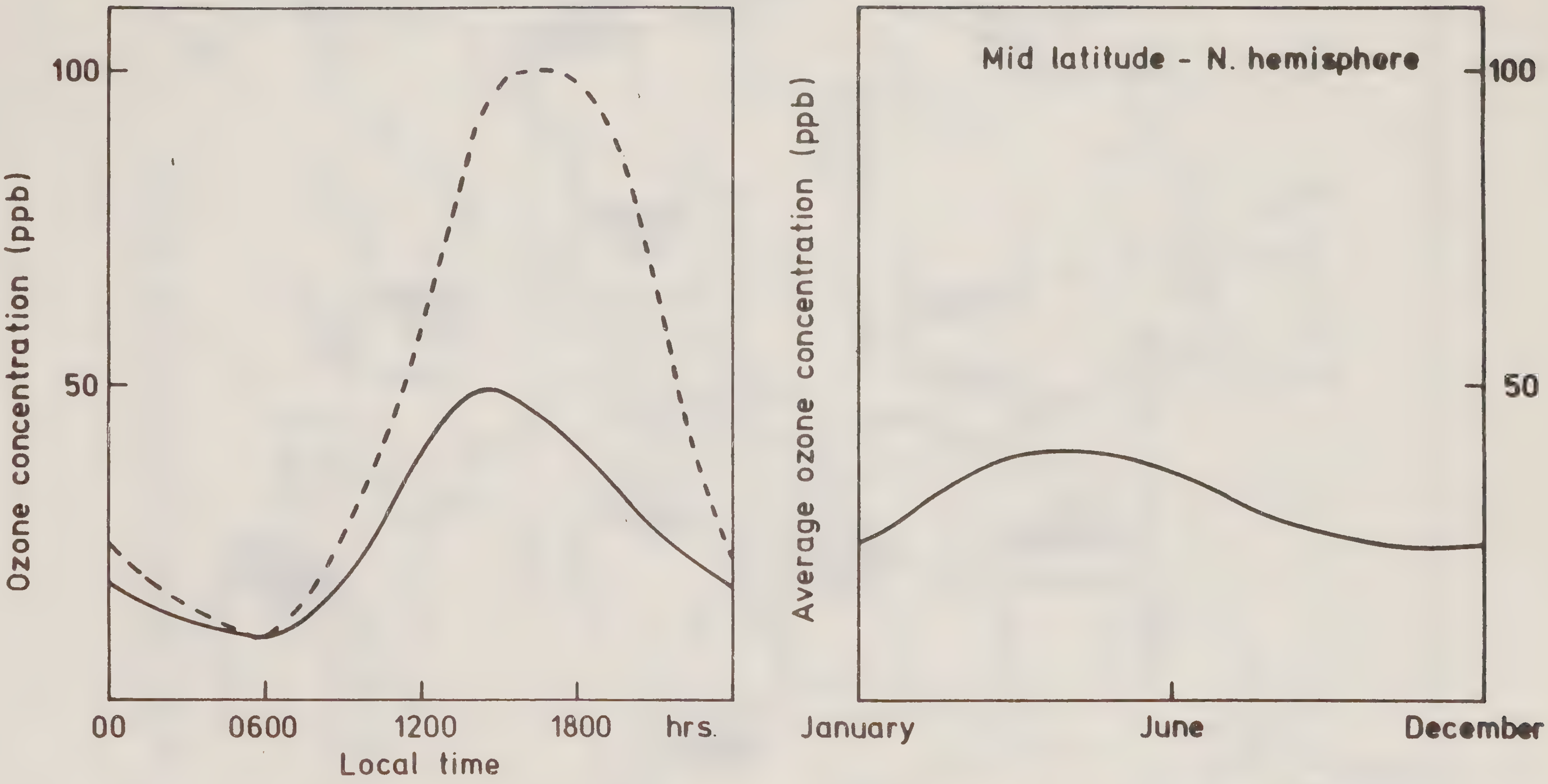

FIG. 1 DIURNAL AND SEASONAL VARIATION OF OZONE NEAR THE GROUND

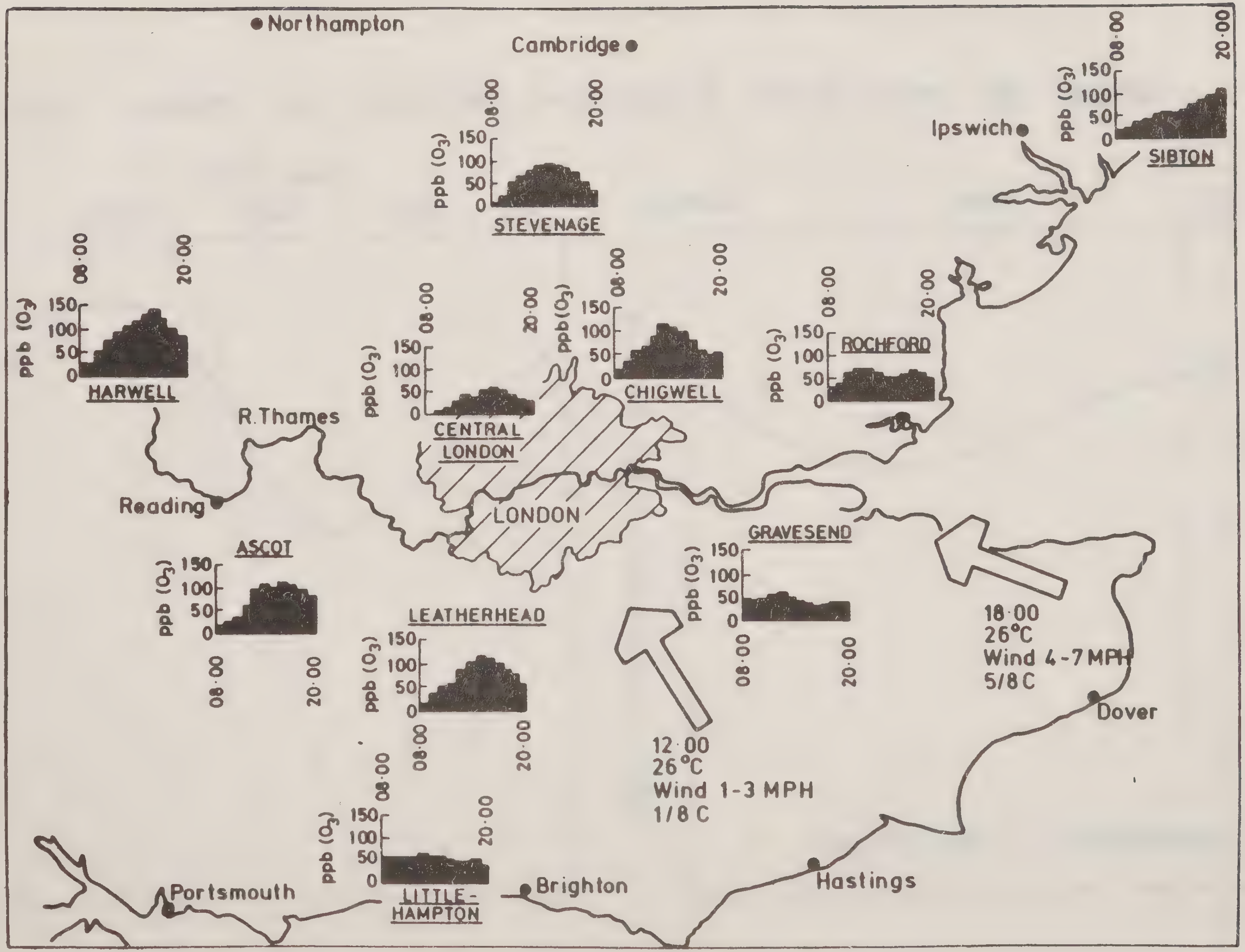

FIG. 2 OZONE RECORDINGS IN THE SOUTH EAST OF ENGLAND - 8TH JULY, 1982

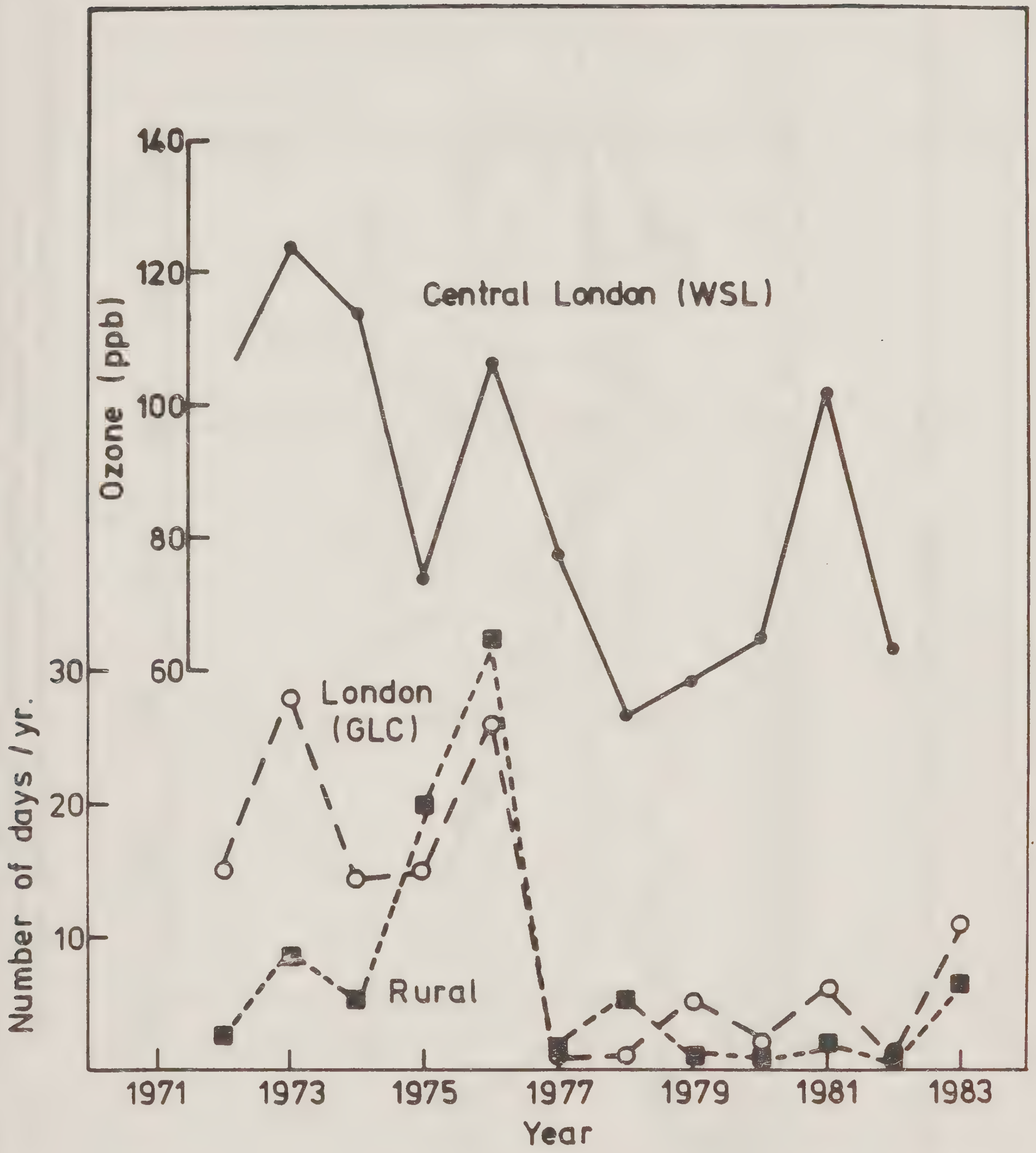

FIG. 3 ELEVATED OZONE CONCENTRATIONS IN S. ENGLAND 1972 - 1983

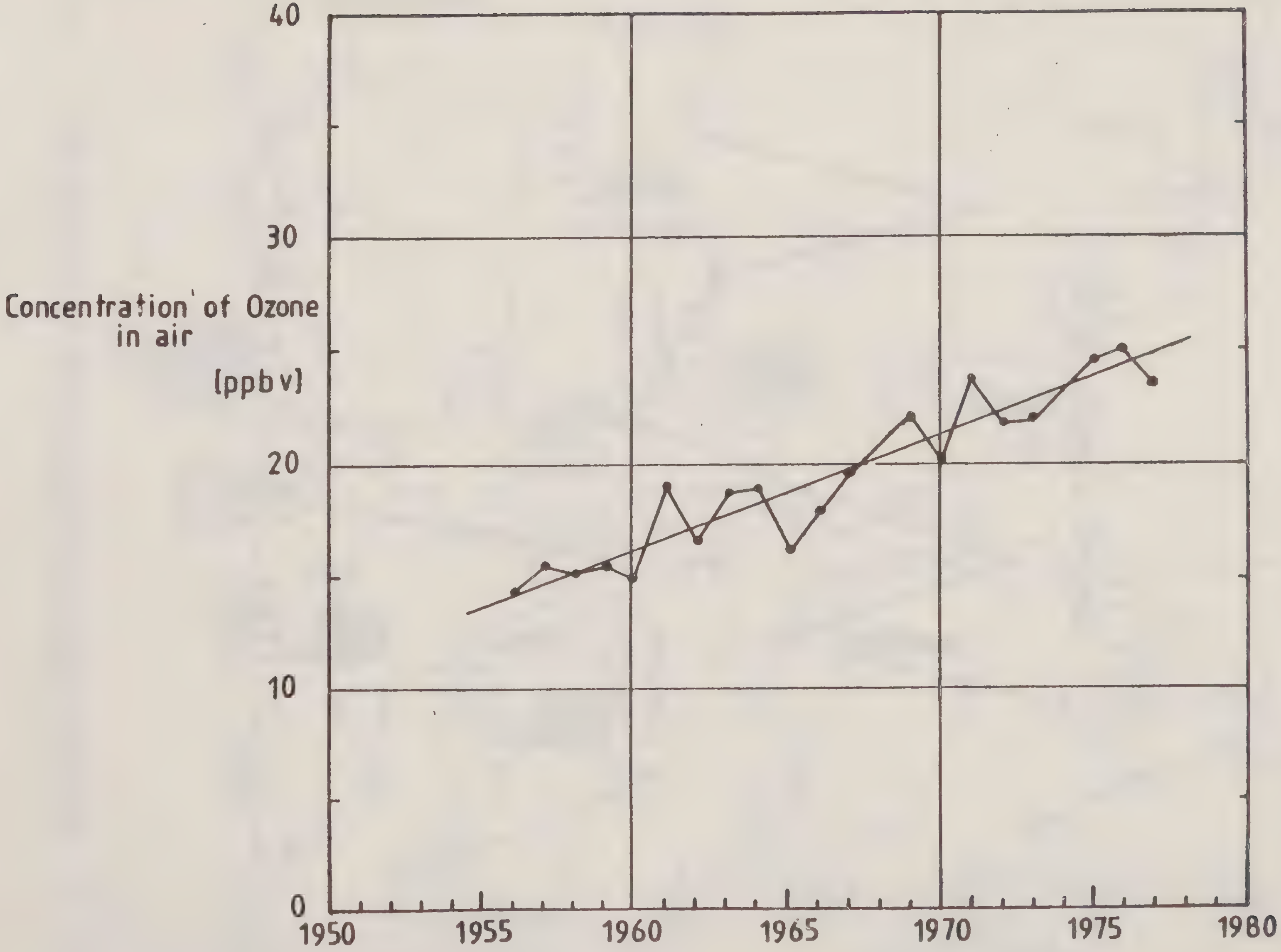

FIG. 4 ANNUAL MEAN GROUND LEVEL CONCENTRATION AT ARKONA G.D.R. (WITH LINEAR REGRESSION LINE)
(From W. Warmbt, "Langjährige Messungen des bodennahen Ozons"
Zeitschrift für Meteorologie Band 29 Heft 1 [1979])

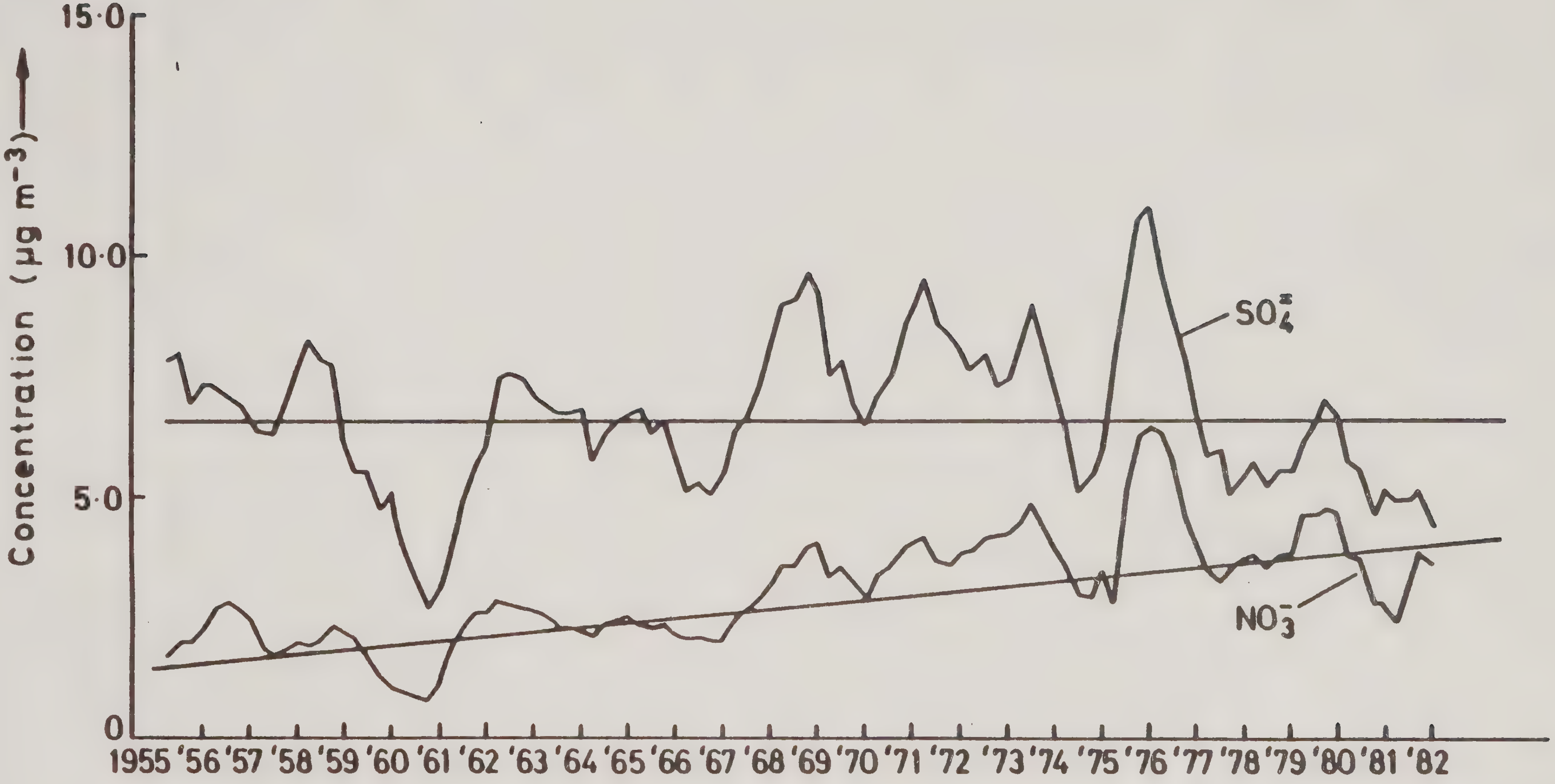

FIG. 5 SULPHATE AND NITRATE AT CHILTON, OXFORDSHIRE, PLOTTED AS FOUR-QUARTERLY MOVING MEANS

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EFFECTS OF AIR POLLUTION ON CROPS AND TREES

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SUMMARY

Historically, studies of the effects of the main phytotoxic gases (SO_2, O_3, NO_x and HF) have focused on determining short-term thresholds for the appearance of foliar injury. There are no regulatory standards in the UK but the peak SO_2 concentrations, even in urban areas, are well below the current USA air quality standard to protect vegetation (500 ppb for 3 h). In contrast, the equivalent O_3 standard (120 ppb for 1 h) is exceeded in most summers particularly in SE England. Recent research has indicated that short term standards may not be appropriate as long-term exposures are now known to produce yield losses in the absence of foliar injury.

With regard to crops, this review concludes that (a) the current EEC standard for SO_2, which is met by all the UK except a few urban areas, is probably adequate to protect most crops from damage by SO_2 alone (b) O_3 concentrations in the south-east in particular, are close to the threshold for effects on some crops and (c) interactive effects of SO_2 and NO_2 are not important at current rural concentrations but interactions between SO_2 and O_3 need further investigation. Research effort is also focusing on the significance of (a) increases in aphid occurrence, frost sensitivity and drought susceptibility at urban SO_2 levels and (b) positive and negative effects on pathogens of winter cereals at urban-fringe SO_2 levels.

Research into the effects of air pollution on forestry has been dominated by the increasing reports from W. Germany of "Neuertige Walschaden - new-type forest decline". Support for the "Ulrich theory" of soil-mediated effects due to acid deposition has declined. Research effort has focused on the possible direct effects of ozone in combination with drought, acid mist or pathogens. Symptoms of the "new-type forest decline" do not occur in the UK according to the Forestry Commission. This review compares the concentrations of air pollutants in the affected forest areas of S. Germany and a rural area in the central UK. The comparison shows that (a) annual mean levels of SO_2, NO_x

and rainfall acidity are greater in the UK; (b) ozone levels are higher in Southern Germany and have risen appreciably in Central Europe over the past three decades. Conclusions concerning effects of ambient levels of SO_2 and O_3 on trees are limited by the paucity of long-term controlled fumigation experiments.

INTRODUCTION

The primary pollutants which have the greatest potential for affecting the growth of crops and trees are sulphur dioxide, nitrogen oxides and hydrogen fluoride. Photochemical reactions between nitrogen oxides and hydrocarbons produce secondary pollutants, of which the oxidants such as ozone may also affect vegetation (Roberts, *et al.*, 1983a). Prior to the Clean Air Act (1956), the concentrations of SO_2 in the large urban areas were high enough to cause visible damage to plants. Urban SO_2 concentrations have declined by more than 50% since that time. Emissions peaked at about 6 million tonnes in 1972 and then declined to 4.2 million tonnes in 1983. In contrast to the decline in SO_2 concentrations, the past decade has seen an increase in concern that long-term exposure to ambient levels of SO_2 and other pollutants may affect the growth of crops and trees. This concern stemmed from the observations in 1972/73 that long-term exposure to SO_2 concentrations, similar to those found in urban areas prior to the Clean Air Act, could reduce the growth of ryegrass without producing visible foliar lesions.

EFFECTS ON CROPS

Research effort has expanded to investigate the possibility of effects at ambient levels, and the extent of interactions with other stresses such as climatic extremes, pests and pathogens (Unsworth and Ormrod, 1982). This research has now progressed to the point where some tentative conclusions can be drawn with regard to (a) threshold concentrations at which there is a reasonable probability that yield losses will occur and (b) dose-response relationships that assist cost-benefit analysis of emission control.

EXTRACTION OF THRESHOLD VALUES

The data from 125 exposures of 21 crops to constant levels of SO_2 alone in chambers were analysed by Roberts (1984) in order to identify threshold values and dose-response relationships. The structure of the data in relation to ambient SO_2 concentrations in the UK in 1976 is shown in Figure 1. Of the 109 data points below 150 ppb (400 ug m^{-3}), only 35 lay within the range of ambient (including urban) 1976 levels in the UK (under 55 ppb-145 ug m^{-3}). Clearly there is a relation between SO_2 level and crop growth with less than 20% of observations below 44 ppb showing effects compared to greater than 80% above 86 ppb. There is a transition zone between 44 and 66 ppb at which about 50% of the observations showed more than a 10% yield loss. It seems reasonable to conclude that SO_2 concentrations over most of the UK have decreased to a point (~ 95% is now below 19 ppb-50 ug m^{-3}) where there is a low probability that SO_2 alone will reduce crop growth. The EEC standards, which were really developed to protect human health, recommend that the yearly median of daily means should be 45 ppb (120 ug m^{-3}) when particulate levels are below 40 ug m^{-3} and 30 ppb (80 ug m^{-3}) when particulate levels are above 40 ug m^{-3}. These standards should be adequate to prevent significant yield losses due to SO_2 alone.

INTERACTIONS BETWEEN SO_2 AND OTHER POLLUTANTS

A. Effects of Filtering Urban Air

Some reviewers have concluded that the mixture of SO_2, NO_2 and O_3 in rural areas has a significant effect on crop yields (Last, 1982). Considerable emphasis in support of this agreement has been laid on the results of early studies which showed that removal of the mixture of air pollutants from urban air (SO_2, NO_2, HF and O_3) using a charcoal-filter, increased the growth of *Lolium perenne* L. However, more recent studies have produced conflicting results so that the data-base from air-filtration studies is not adequate to conclude that air pollution at present UK levels has significant effects on agricultural production (Figure 2).

The first quantitative evidence that urban air pollution in the UK may produce chronic or hidden injury came from filtration studies carried out in Manchester in the early 1950s (Bleasdale, 1973). Filtering urban air (containing up to 60 ppb of SO_2) through a water-spray improved ryegrass yields by 20-40% after 6-12 months growth.

A similar study, using charcoal filters instead of a water-scrubber, was carried out near Sheffield in the early 1970s. Crittenden and Read (1978a and 1978b) concluded that removing 15-25 ppb SO_2 resulted in a similar increase in ryegrass yield. However, interpretation of these greenhouse studies is made difficult by the lack of replication and the large effect of the chambers on environmental conditions. In addition, monitoring of short-term peaks of SO_2 and the levels of other phytotoxic gases was inadequate.

Subsequently, open-top chambers have replaced greenhouses in order to reduce the 'chamber effect' on the microclimate around the crop. This type of chamber has been used in Bedfordshire to study the local effects of emissions from brickworks (Buckenham *et al.*, 1982). Barley grown in open-top chambers supplied with filtered air produced greater straw and grain yield than barley grown in unfiltered chambers at four out of five harvests between 1975 and 1979. The seasonal mean concentration of SO_2 varied between 19 and 30 ppb but it is likely that the 15-40% yield losses were caused by the combined effects of concurrent peaks of SO_2 and HF present in plumes from local brickworks.

The design of open-top chambers has been further developed by Roberts *et al.* (1983b) in order to assess the effects of current levels of urban air pollution around Merseyside on grass productivity, The results of filtration studies carried out between 1978 and 1980 suggest that the effects on summer growth were less than previously thought, although yield losses were found in the early spring growth period (Colville et al., 1983). It is not clear yet whether these were caused by the accumulative effects of urban air pollution over the winter or exposure during spring growth.

It will always be difficult to assess which pollutant or combination of pollutants is responsible for any measured yield differences between filtered and unfiltered chambers. The results must, therefore, be interpreted with caution and with due regard to the results of controlled fumigation experiments.

B. Effects of SO_2 When Mixed with Other Gases

(i) $SO_2 + NO_2$

In general, the addition of two pollutants, at concentrations above the threshold for long-term effects on growth of each gas separately, produce additive or more-than-additive reductions in yield. This has been clearly demonstrated for the interactive effect of more than 60 ppb SO_2 and NO_2 on pasture grasses growing slowly over winter (Ashenden, 1979). However, mixtures of $SO_2 + NO_2$ at concentrations below the individual gas thresholds do not appear to produce such large interactive effects. For example, Whitmore and Mansfield (1983) reported that while 62 ppb $SO_2 + NO_2$ reduced *Poa pratensis* growth over winter, final yield was stimulated after the more rapid summer growth. Similarly, Lane (1983), using fluctuating concentrations of SO_2 and NO_2 more typical of urban areas in the UK, found no effects of single gases or mixtures of 31 ppb SO_2 and 23 ppb NO_2 on three grass species. Similarly, Roberts, Darrall and Lane (1983) simulated the daily fluctuations of SO_2 and NO_2 reported from urban and rural areas and, after 8 months, found no effects or a stimulation of winter barley, winter wheat and ryegrass with mixtures below 30 ppb $SO_2 + NO_2$, but some yield reductions with mixtures above 45 ppb $SO_2 + NO_2$.

(ii) $SO_2 + O_3$

There is a greater possibility of interactive effects of SO_2 with ambient ozone levels although there is very little experimental evidence for the UK. The British Isles has neither the volume of emissions nor the climatic conditions required to produce photochemical smogs on the scale experienced in California. However, in hot, dry summers the magnitude of peaks and the frequency of episodes may not be very different from the eastern United States. The ambient ozone levels, particularly in the south-east of England may thus be close to the concentrations required to reduce the yield of some crops.

Concentrations of SO_2 alone are too low in rural areas to affect crop yields but these could become significant if there are interactive effects between SO_2 and O_3 at concentrations close to the threshold for O_3 phytotoxicity.

O_3 concentrations in parts of the UK have produced visible injury on the very sensitive Bel-W3 tobacco which was bred as an O_3 indicator. Ashmore _et al_. (1978) carried out a survey of the O_3 distribution in the UK in 1977 and 1978 using this cultivar as a bioassay species. In both years, the survey showed that O_3 levels were above the natural background of 20-30 ppb over most of the UK except for northern Scotland. The degree of injury was related to the hours of sunshine and wind direction from urban areas. Ashmore _et al_. (1980) have reported infrequent appearances of ozone injury on commercial crops around London, particularly on legumes such as pea, lucerne and clovers, when the maximum 1 h concentration reached 120-140 ppb.

There is considerable support in the North American literature for effects on growth, stem elongation, leaf area, root weight, flower production as well as fruit and seed set in a range of crops after long-term exposures to >100 ppb O_3. Current interest lies in quantifying the effect of long-term exposure to between 50 and 100 ppb. Heagle and Heck (1980) argued that for a given day, the diurnal cycle is quite regular and the changes in O_3 concentrations during the period of maximum absorption (9.30 am to 4.30 pm) are quite small. Consequently, the daytime 7 h mean (9.30 am to 4.30 pm) is most relevant to long-term effects on crop growth. A series of experiments was carried out in open-top chambers to determine the effect of seasonal 7 h day^{-1} mean O_3 concentrations ranging from 50 to 150 ppb on the yield crops. The O_3 dose (seasonal 7 h day^{-1} mean O_3 value) for a significant yield decrease was between 60 and 100 ppb for winter wheat and spinach cultivars, between 700 and 110 ppb for soybean cultivars and between 110 and 150 ppb for field corn.

Heck _et al._ (1982 and 1983) used a similar approach as part of the National Crop Loss Assessment Programme carried out at seven sites across the USA. Results of the regression analyses are shown in Figure 3. Wheat and corn were quite resistant but 10% yield reductions for 4 spinach and turnip cultivars occurred at 50 and 45 ppb respectively.

It is difficult to extrapolate these results to Europe due to differences in crop cultivars and climatic conditions. For comparison, the 7 h (10.00 am - 5.00 pm) daily mean from 1 May to 31 September 1981 (a fairly low O_3 season) was about 30 ppb in SE England but probably reached 50 ppb in the exceptional summer of 1976.

Interactions of SO_2 + O_3 have been studied by adding SO_2 to the filtered or unfiltered air supplied to open-top chambers. In the study by Oshima (1978), carried out at Riverside (California), 100 ppb SO_2 was added to an ambient, filtered or part-filtered airstream in replicated chambers for 6 hours each day. SO_2 alone had no effect on the crop _Phaseolus vulgaris_ (red kidney bean), but addition to 50% filtered air significantly reduced both total plant dry weight and seed dry weight. Heggestad and Bennett (1981) added three SO_2 concentrations (60, 120 and 300 ppb) for 6 h per day to the background of ambient ozone at Beltsville (Maryland), and found a linear correlation between increasing SO_2 concentration and decreasing yields of three *Phaseolus vulgaris* (snap bean) cultivars. Yield losses arising from the SO_2 treatments were threefold greater in the presence of ambient oxidants than when added to charcoal-filtered air.

The only studies in the UK in which SO_2 was added to the background concentrations of NO_x and O_3 present in rural areas was carried out in open-top chambers by Roberts *et al*. (1983b) and Colvill *et al*. (1983). These authors concluded that it was necessary to add 45 ppb SO_2 continuously to unfiltered rural air to produce significant and repeatable reductions in the yield of *Lolium perenne*. The recent development of field fumigation systems (Greenwood *et al*., 1982; McLeod *et al*., 1983) will provide further information on the long-term effects of SO_2 added to the background of other pollutants found in rural areas.

INTERACTIONS BETWEEN SO_2 AND OTHER STRESSES

It has been demonstrated that grasses are most susceptible to prolonged low-level exposures of SO_2 during periods of slow growth over winter. Davies (1980) found that while low irradiance (near the compensation point) reduced SO_2 absorption by the grass, *Phleum pratense* (timothy), the metabolic capacity to detoxify the absorbed SO_2 was reduced even more. Mansfield and Jones (1984) proposed that the consequent lowering in net assimilation rate is first seen as a reduction in root growth, which may increase drought susceptibility. In addition, the lower assimilate available for leaf growth may be compensated for by an increase in leaf area per unit weight, which could lead to increased frost sensitivity.

The interaction with drought susceptibility has yet to be demonstrated experimentally but Bleasdale (1973) noted that SO_2 reduced the winter hardiness of ryegrass in urban areas. This was confirmed recently by Davison and Bailey (1982) who found that exposure to 94 ppb SO_2 for 35 days at low irradiance reduced the survival of Lolium perenne subsequently exposed to sub-zero temperatures. Increased frost injury occurred on winter wheat leaves exposed over winter to 100 ppb SO_2 under field conditions (Baker et al.,1982).

Frequent cutting is another stress of importance particularly for amenity swards. Bell (1980) found that exposure to 180 ppb for 42 days in a wind tunnel had no effect on ryegrass swards. However, similarly exposed swards which were cut weekly showed a 22% yield reduction over the six harvests and, at the final harvest, the yield was reduced to less than 20% of the controls.

Many observations have been made of increased population densities of herbivorous insects in areas subject to air pollution. Recently, Dohmen et al. (1984) showed that ambient urban levels of SO_2 + NO_2 in central London increased the growth of the black bean aphid Aphis fabea. and that this increase was due to metabolic changes in the host plant. In contrast, there have also been many observations of decreased frequency of plant pathogens in urban areas. McLeod and Fletcher (pers. comm.) have recently found both increased and decreased frequency of winter cereal pathogens in plots fumigated with SO_2 using an open-air fumigation system. The significance of these observations for the host plant is not yet clear and the causal mechanisms remain obscure. These effects will be of considerable importance if they occur at SO_2 levels which are lower than those required to affect the yield of the host plant.

EFFECTS ON TREES

Practical problems in forestry have been encountered throughout Europe for many decades around large urban areas with high emissions of SO_2 and smoke and close to poorly-dispersed point-sources of SO_2 and/or HF. These areas were fairly localised and the problems have been tackled by abandoning commercial forestry in severely-affected areas, adoption of appropriate management techniques - such as use of resistant species or cultivars - or financial compensation. With the decrease in smoke and SO_2 levels in urban areas, these problems have generally become less severe over the past two decades. However, in the past 5-10 years a new-type of forest decline has been reported from supposedly "clean-air" regions in West Germany and elsewhere in Central Europe. This was initially attributed to direct effects of SO_2 and/or acidification of soils caused by acidic precipitation. It now seems likely that the causes are more complex and research effort is currently focused on the role of ozone in combination with drought, frost, pathogens or acid mist.

"WALDSCHÄDEN" - NEW-TYPE FOREST DECLINE IN WEST GERMANY

An increasing decline of silver fir has been recorded since the beginning of the 1970s. This was seen first in Bavaria, and later in other parts of Southern Germany (e.g. Black Forest) and Central Europe (VDI., 1983 L. Blank, pers. comm., Binns and Redfern, 1983).
The main decline symptoms are:

(i) gradual discoloration and subsequent loss of needles, from the base to the top and from inner to outer branches
(ii) premature growth reduction and formation of "stork's nest"
(iii) branch dieback in lower crown and formation of epicormic shoots
(iv) development of a wet core
(v) damage to the fine root system and mycorrhiza
(vi) Mg and Ca deficiency in older needles

Fir dieback increased dramatically during the hot and dry summer of 1976 and now affects virtually all stands in Germany. It is reported not only from Germany (East and

West), but also other European countries including Poland, Czechoslovakia, Italy, Switzerland and Austria. As this disease was confined to a single species (silver fir), it was consequently named "fir dieback".

Less extensive episodes of decline of silver fir (Abies alba) have been documented for two centuries, with localized dieback recorded in 1858, 1886-1894, and 1922-1923.

Since 1976, however, similar damage symptoms have been reported for other species at various locations in Germany. In particular Norway spruce (Picea abies), Scots pine (Pinus sylvestris), and common beech (Fagus sylvatica) are affected. This "New Forest Decline" is now widespread. Affected trees are no longer confined to higher altitudes where it was first noticed (at 800-1,000 metres in the Bavarian Forest and at 500-800 metres in the Black Forest). All age classes are affected but the symptoms are more severe on older trees. There is rarely a uniform pattern of damage in a forest stand, and severely affected trees can be found next to healthy looking ones.

To obtain a clear piture of the extent and severity of damage, Forest Damage Inventories were carried out in 1982 and 1983; the 1983 Inventory was more detailed than the previous one (in 1982 approximately 60% forest area was assessed). The extent and severity of damage was assessed using a system of three damage categories (category I = slight damage, category II = damaged, category III = severe damage).

The most striking result of the 1983 inventory was the drastic increase in the total damage area from 8% in 1982 to 34% in 1983 (Table 1). This was mainly due to an increase in damage category I (slight damage) from 6% to 25%. Severe damage increased from 0.5% to 0.9%. Coniferous trees were more often damaged than deciduous trees, with fir, pine, and spruce being most affected.

The 1983 Forest Inventory has been criticized for:

(i) its wording, which attributes all damage to air pollution as a major or secondary cause,
(ii) the use of criteria not specific for air pollutant damage,
(iii) the procedure of assessment, with foresters classifying their forests (and their own forest management practices).

It has been suggested that the 34% estimate of area damaged in the whole of the Federal Republic may be too high. It is also likely that increased awareness of possible damage led to this higher figure compared with the previous year. Despite the controversy about the actual percentages and the comparability of the 1982 and 1983 inventories it is, however, undisputed that the decline is increasing both in severity and geographical extent.

PROPOSED CAUSES OF "NEW FOREST DECLINE"

Direct Effects of Acid

Direct effects of sulphuric and nitric acids are not generally considered to be primarily responsible for the damage. The pH levels of rain in affected areas are too high to cause damage even to sensitive plants (Jacobson, 1984). In addition, there has been no decrease in pH of rain in recent years in either the Bavarian Forest or the Black Forest (Figure 4).

Soil Acidification

The most widely-known hypothesis was based on a suggestion that wet and dry acid deposition affects the soil by destroying its buffering system. This would lead to leaching of nutrients and mobilization of toxic aluminium ions and eventually to damage of the fine root system of trees (Ulrich and Pankrath, 1983). This hypothesis of soil-mediated effects was based on a comprehensive field study of nutrient cycling in the Solling Plateau (North Germany), and Ulrich extrapolated these results to other areas. This theory has been extensively criticised on grounds that damage occurs to trees on a variety of soils including those in calcareous areas with characteristics significantly different to those of the Solling. The hypothesis cannot explain both the temporal and geographical development of the forest decline, and is therefore no longer generally accepted as an overall explanation.

DIRECT EFFECTS OF SO_2 AND NO_X

Only comparatively small areas in West Germany next to the East German and Czech borders are exposed to high SO_2 levels, with mean annual concentrations between 10-40 ppb SO_2 (27-108 ug m^{-3}) and episodes of much higher concentrations (up to 560 ppb). Damage in these areas has been attributed for some time to the direct action of pollutants. The Czech forests of the "Erzgebirge" show extensive signs of SO_2 damage, caused by uncontrolled emissions from power stations and industrial plant burning high sulphur coal (~5% S) in East Germany and Czechoslovakia.

Materna (1973) related qualitative measurements of visible injury, needle abscission and growth of Norway spruce (Picea abies) to SO_2 concentrations monitored continuously over the period 1969-1971 at 10 sites in four areas of the Erzgebirge region of Czechoslovakia. Accelerated needle loss and higher mortality of isolated trees, but no growth reductions, were reported for areas with annual mean concentrations of 10-19 ppb. Moderate reductions in growth occurred at 19-38 ppb and severe foliar injury and growth reductions occurred at above 39 ppb. These thresholds are lower than those reported in studies around urban areas and have been ascribed to (a) greater sensitivity of spruce in the extreme climatic conditions at 700 m altitude typical of the Erzgebirge study area and (b) infrequent high peak SO_2 levels close to such large poorly-dispersed point-sources.

Direct effects of SO_2 and NO_x are not suggested as causes in so-called "clean air areas" such as the Black Forest and parts of the Bavarian Forest.

The Schauinsland (Black Forest) and the Brotjacklriegel (Bavarian Forest) sites are both designated as "clean air monitoring stations" by the German EPA. Nevertheless, both these areas show extensive damage. Annual concentrations of SO_2 (< 5 ppb) and NO_2 (< 4 ppb) were well below those reported to affect plant growth (UBA, 1984) and showed no upward trend between 1973 and 1983 (Figure 5).

EFFECTS OF OZONE

It was recently suggested by Arndt that ozone may play a major role in the forest decline (Arndt and Lindner, 1981). This hypothesis was taken up by Prinz et al. (1982) who suggest the following mode of action:

> Exposure to ambient ozone levels damages cell membranes, resulting in an increased leaching of ions by acid fog and acid rain. Ozone also causes damage to chlorophyll, and thus reduction in carbohydrate production and root growth. This reduces the ability to compensate for leached nutrients by increased uptake (figure 6).

Prinz et al.(1982) pointed out that ambient ozone levels in severely damaged forest areas of West Germany are remarkably high and comparable to parts of the USA where ozone is known to cause forest injury. Recent measurements show that daily mean ozone levels in "clean air areas" of the Southern Black Forest and the Bavarian Forest are often above 50 ppb (100 ug m^{-3}) (Figure 7). There is, however, a paucity of data, as ozone was only recently included in the catalogue of air pollutants being continuously measured at ambient air monitoring stations operated by the German Environmental Protection Agency.

There is only one data set which gives a clear idea of the trend in natural background ozone concentrations in Europe over the past 20 years. Ozone levels at Arkona on the Isle of Rugen in the Baltic Sea off the German Democratic Republic, an area not affected by any local air pollution, increased by 60% between 1956 and 1977 (Figure 8) (Warnbt, 1978). A similar trend has been reported for two other stations in forest areas of East Germany, and can be assumed for forest sites in West Germany and neighbouring countries as well. This coincides with the steady increase of NO_x and hydrocarbon emissions from motor vehicles, which react with sunlight to produce ozone during transport over long distances from urban areas. The ozone then affects remote areas, particularly at higher altitudes. Indeed, data from the Bavarian Alps show comparatively low and steady O_3 concentrations between 1977 and 1982 in a valley, and higher concentrations with a trend towards an increase at higher altitudes (Figure 9). It was at high altitudes of remote forest areas where damage was first noticed. Ozone levels remain high throughout the day and night at the high altitude sites whereas the valley sites show the normal diurnal pattern with peak levels in the early afternoon (Figure 10).

There are, however, some inconsistencies and gaps in the photochemical oxidant hypothesis. Little is known on the relative susceptibility of the species concerned, and conifers, which were thought to be more resistant than deciduous species, appeared to be affected first. The symptoms are similar to O_3 injury seen on trees in California in some respects but there are a number of important differences. Hence the proposal has been made that the decline is caused by ozone acting in combination with other stresses such as acid mist, drought, frost or pathogens. Controlled experiments are needed to verify the largely circumstantial evidence on which these hypotheses are based.

CLIMATE AND DISEASE

This cursory survey of the present state of our knowledge has so far centred around the role of air pollutants. There appears to be a consensus amongst scientists that they play a major, and probably the key role in Germany's forest decline. There are, however, at least two other factors that deserve careful consideration - climatic stresses and disease organisms. The series of dry and hot years experienced during the last decade has certainly affected tree vitality, probably by lowering the resistance to attack by pathogens. Hot summers in Germany's continental climate are generally followed by harsh winters, often with temperatures below -10°C. Drastic changes in temperature may be particularly important - as on New Year's Eve of 1979 when the temperature in large areas dropped by almost 20°C within hours.

As the number of trees affected by fungal infections has markedly increased over the last few years, it has been suggested that pathogens (fungi, bacteria, viruses, mycoplasms) may be of primary importance (Rehfuess, 1983).

THE UK SITUATION

The situation in the UK differs markedly from that in Germany. According to recent statements of the Forestry Commission (e.g. Binns, 1984) British forests are not affected by the decline symptoms as seen in Germany and other parts of Central Europe. There are occasional episodes of localized damage which can clearly be attributed to known causes such as exteme climatic conditions or local sources of pollution. A comparison of pollution monitoring data from the affected forest areas of Bavaria, the Black Forest and the Central UK shows that (a) annual mean levels of SO_2, NO_x and rainfall acidity are greater in the UK and (b) ozone levels are higher in S. Germany.

In Britain, large-scale deforestation occurred during the pre-industrial period, so that when air pollution from coal-burning rose sharply during the middle of the nineteenth century there were few surviving remnants of natural woodlands in the affected areas: Sherwood Forest and Cannock Chase were the exceptions. In general, new planting by the Forestry Commission avoided those areas where levels of sulphur dioxide in winter exceeded a mean concentration of 32 ppb (85 ug m^{-3}) (Lines, 1984). The decision to forego planting in extensive upland areas which were otherwise suitable, particularly in the industrial Pennines, was followed by a series of trial plantations to see if pollution effects could be mitigated by selection of suitable provenances, fertilization or ground preparation. Trial plantings were established between 1951 and 1953 at sites typical of some 100,000 ha in the south-central Pennines between Bolton, Leeds and Sheffield. Growth was usually slow over the first decade and the trees appeared to suffer more from wind exposure than could be expected from measurements of wind velocity. In general, there was a broad negative correlation between tree growth and rate of sulphation of lead dioxide candles and the annual mean SO_2 concentrations were in excess of 50 ppb (130 ug m^{-3}). Nevertheless, the problem of separating the effects of exposure from those of air pollution and the subsidiary problem of separating effects of gaseous and particulate pollution has not been satisfactorily resolved.

There has been a considerable decrease in smoke and SO_2 concentrations in this area since 1960 and this has been paralleled by improvements in the performance of trial plantations. For example, SO_2 concentrations at Helmshore decreased from > 60 ppb prior to 1960 to < 25 in 1980/81 (Horne, pers. comm.). Further trials in 1963/64 and 1972 showed much-improved growth, particularly for Picea sitchensis (Sitka spruce), potentially the most economic crop for this region.

The Pennines are probably the region most severely affected in the UK by exposure to a variety of gaseous pollutants and climatic extremes. Most parts of the country receive much less pollution. Data from Bottesford, a monitoring station in rural Leicestershire (Figure 5), show annual mean SO_2 concentrations of approximately 11 ppb (30 ug m^{-3}) and NO_2 concentrations of around 10 ppb (20 ug m^{-3}) for the period from 1978 to 1983 (Martin and Barber, 1981 and 1984; Martin, pers. comm.), This is above comparable levels monitored in remote forest sites of Southern Germany, but well below levels causing damage (IERE, 1981). The rainfall acidity at Bottesford averaged around pH 4.2.-4.5, within the range reported from German sites (Figure 4). The measurements of ozone concentrations at Bottesford gave annual means of 20-30 ppb O_3, well below those reported from Germany which may average 40-60 ppb particularly at remote upland sites (Figure 7). The recent Forestry Commission conclusion that British forests do not show symptoms similar to those reported from the Continent would be consistent with the ozone hypothesis. Nevertheless, there is still a need for fundamental research on the effects of air pollutants, particularly SO_2 and O_3, on forestry in both the UK and W. Germany.

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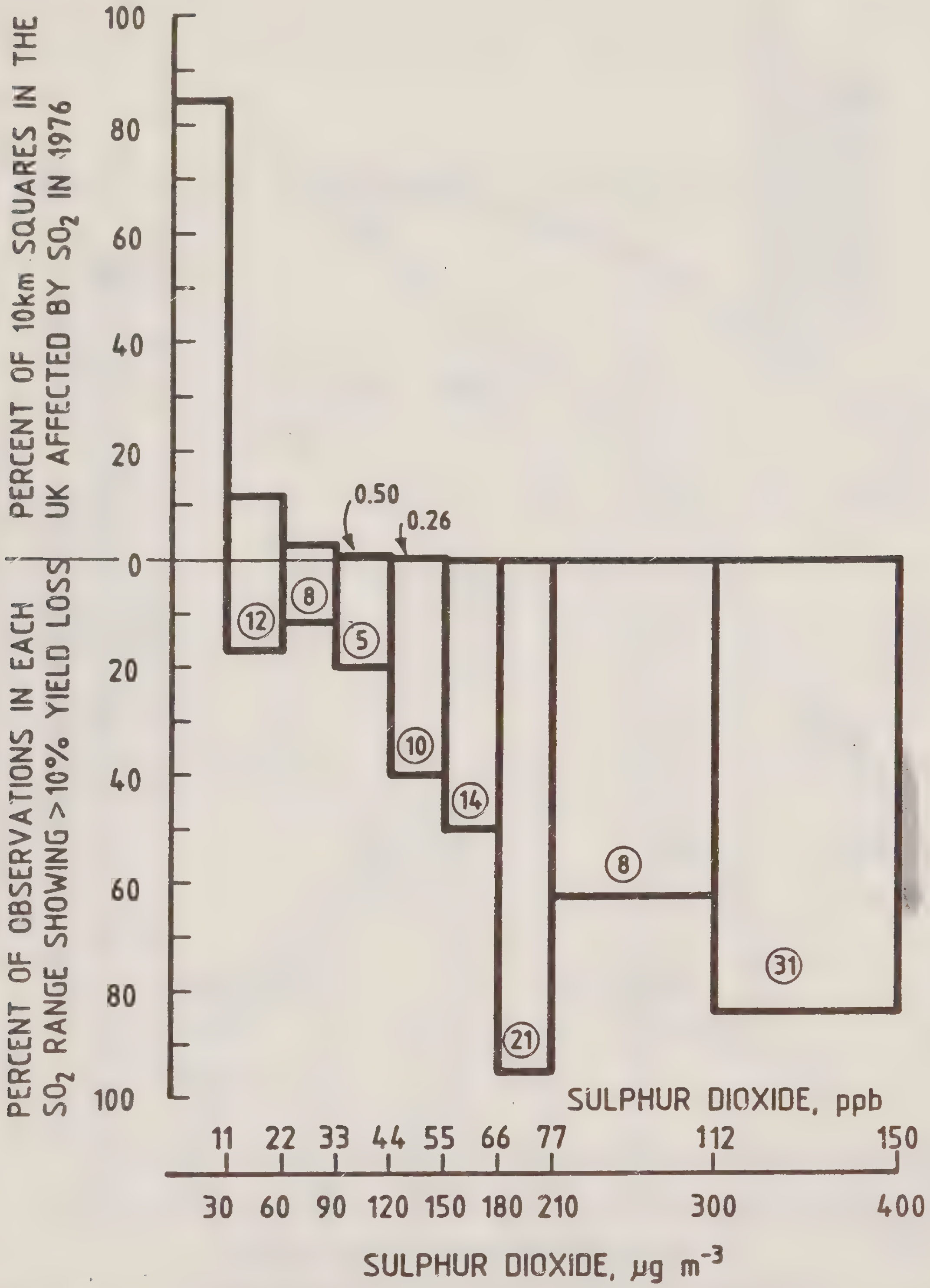
Table 1: Forest Damage Inventories 1982 and 1983

New Forest Damage in 1982 and 1983 According to Damage Categories

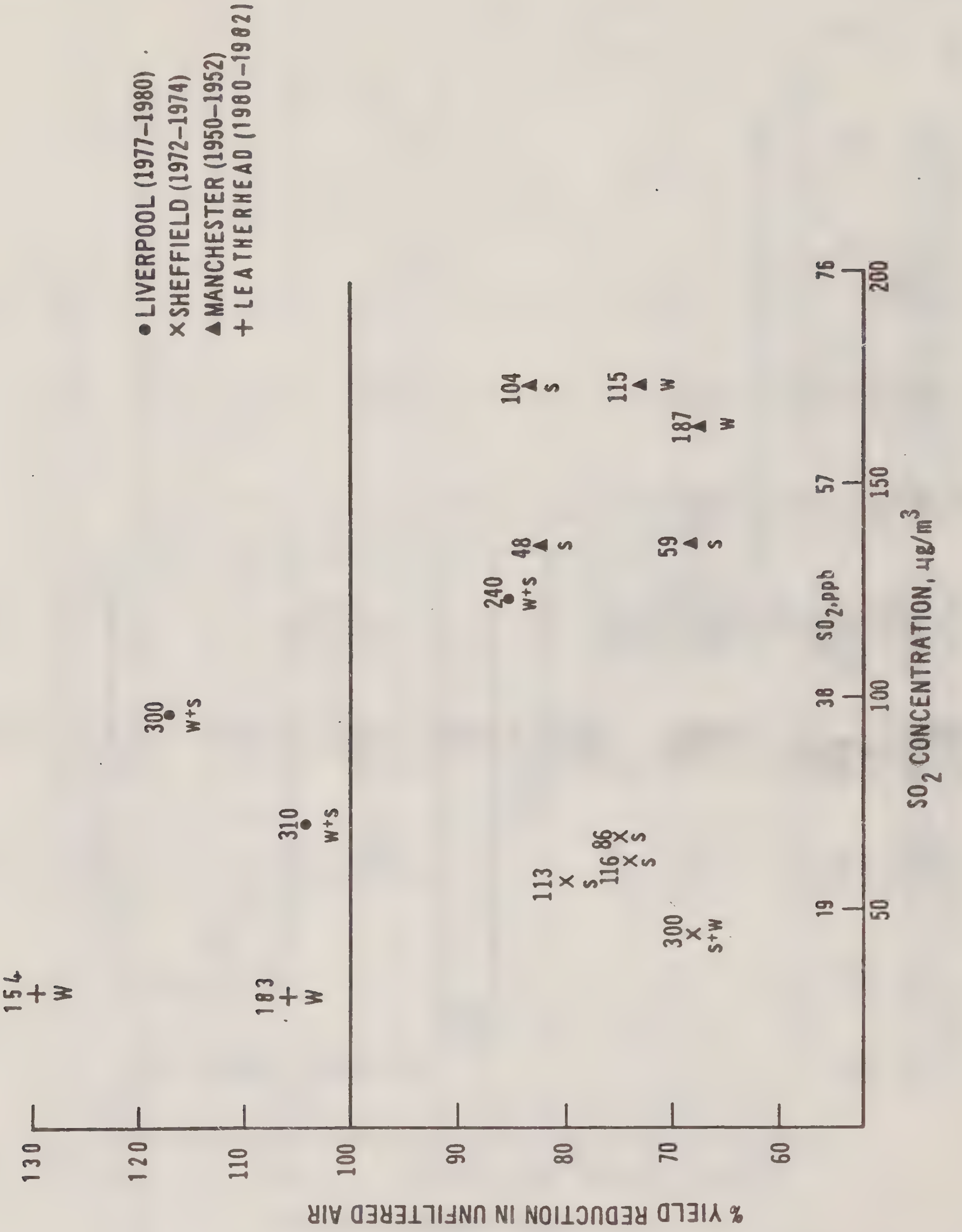
	1982	1983	1982	1983	1982	1982
	Damaged Area					
	mio. ha		% Forest Area		% Total Damage Area	
Category 1	0.419	1.845	6	25	75	72.5
Category 2	0.108	0.635	1.5	8.5	19	25
Category 3	0.035	0.064	0.5	0.9	6	2.5
Total (1 + 2 + 3)	0.562	2.545	8	34	100	100

FIGURE 1



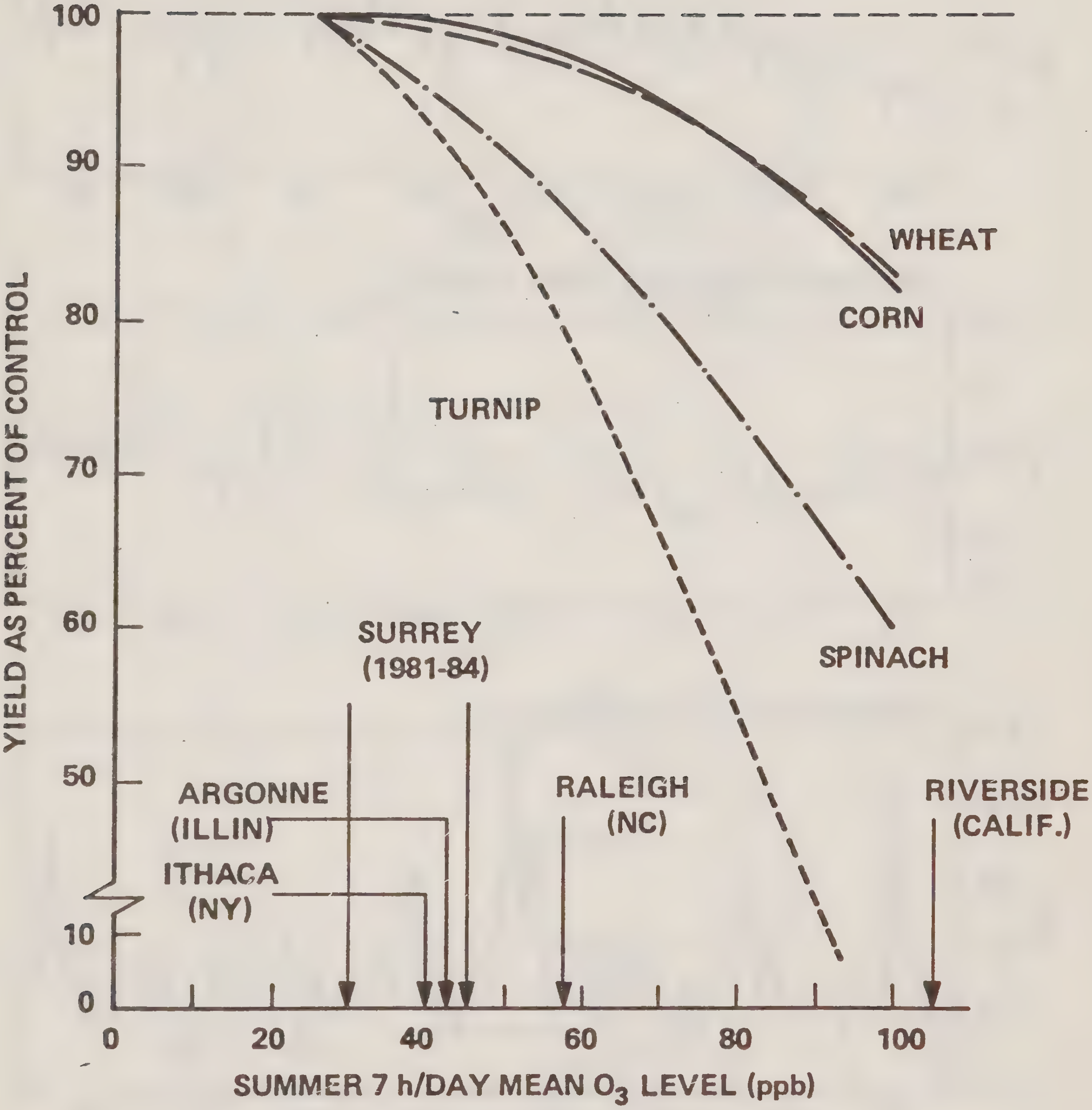
Effects on crop growth of continuous long-term exposures to SO_2 alone in chamber studies plotted against SO_2 concentrations in different areas of the UK in 1976. The circled figures represent the number of studies in each concentration range. For original data on crop responses to SO_2 see Lane (1983), Tables 3.1; 3.2 and 3.4 and IERE (1981), Tables 3.9 and 3.10. For original data on SO_2 distribution in 1976 see SARU (1980).

FIGURE 2



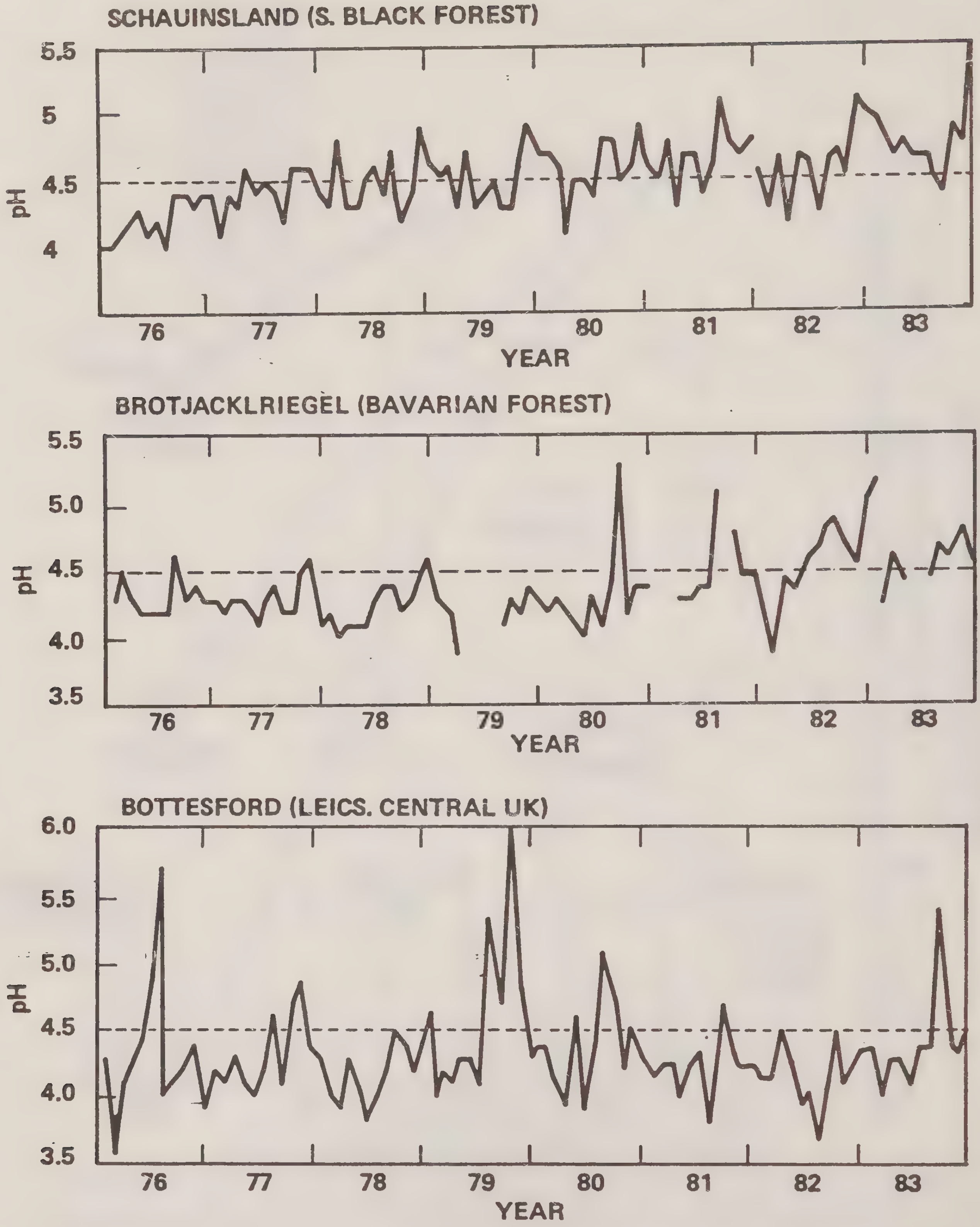
Effects of urban air pollution in the UK on the growth of Lolium perenne as determined from differences in yield in filtered and non-filtered air. Data for Liverpool from Roberts et al. (1983) and Colvill et al. (1983). Data for Sheffield from Crittenden and Read (1978). Data for Manchester from Bleasdale (1973). Data for Leatherhead from Lane (1983).

FIGURE 3



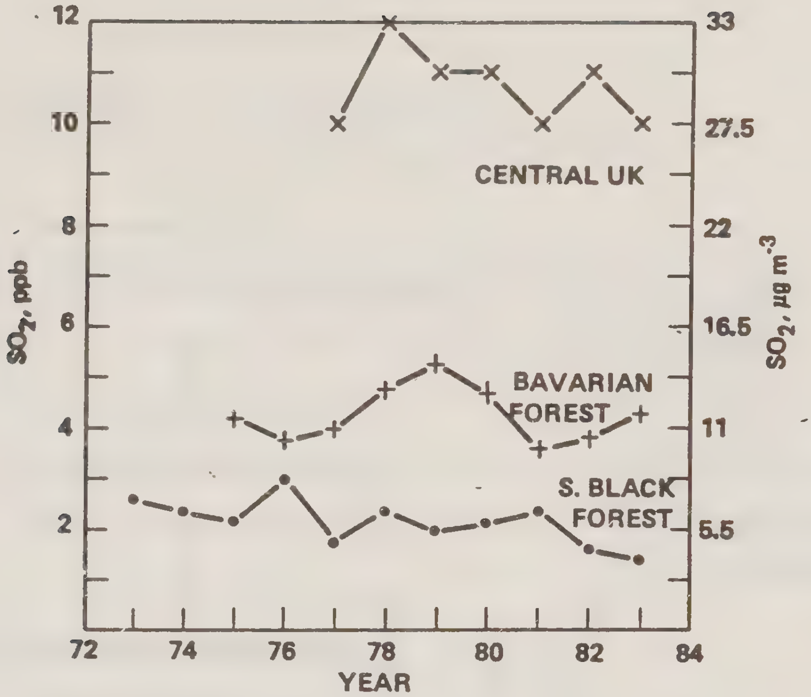
Effects of ozone fumigations (for 7 hr day^{-1} over the growing season) on crop yields in open-top chambers and comparable ozone data for the USA and UK (redrawn from Heck et al., 1983).

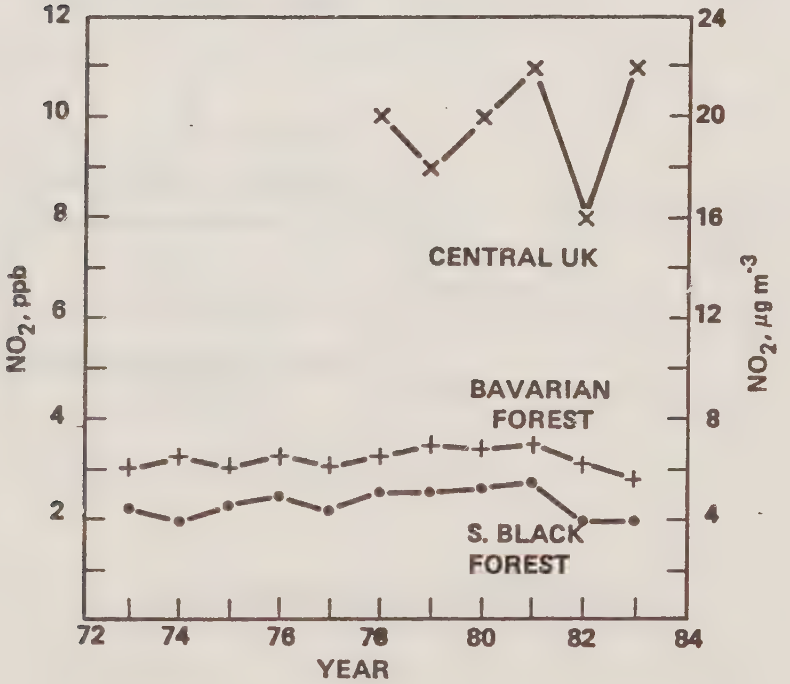
FIGURE 4



Acidity of wet deposition (monthly samples) in the Black Forest (Schauinsland), or the Bavarian Forest (Brotjacklriegel) (UBA, 1984) and Central UK (Bottesford) (Martin and Barber, 1981 and 1984 and Martin, pers. comm.).

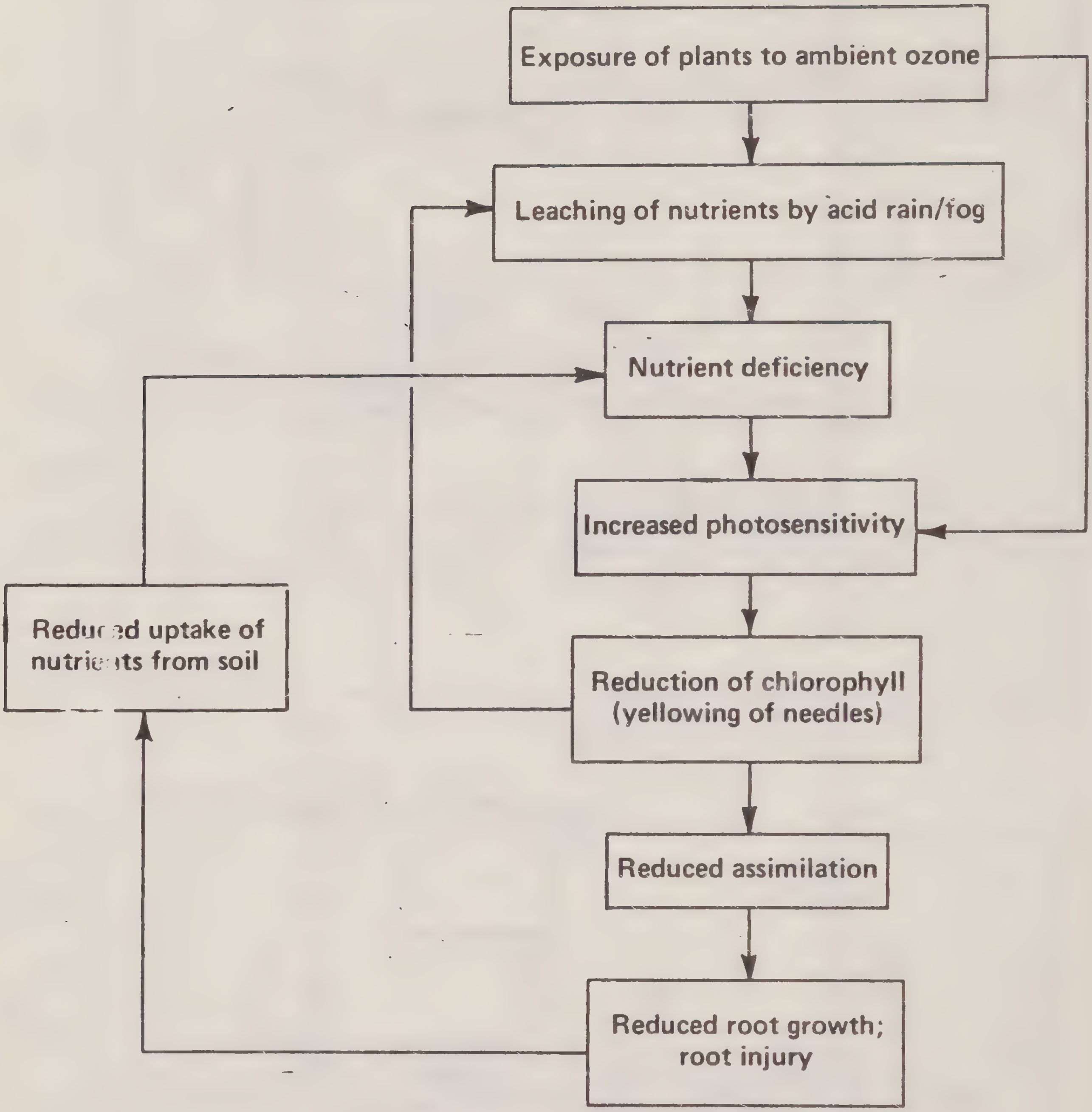
FIGURE 5





Mean annual concentrations of SO_2 and NO_2 in the Black Forest (Schauinsland), the Bavarian Forest (Brotjackriegel) (UBA, 1984) and Central UK (Bottesford) (Martin and Barber, 1981; 1984 and Martin, pers. comm.).

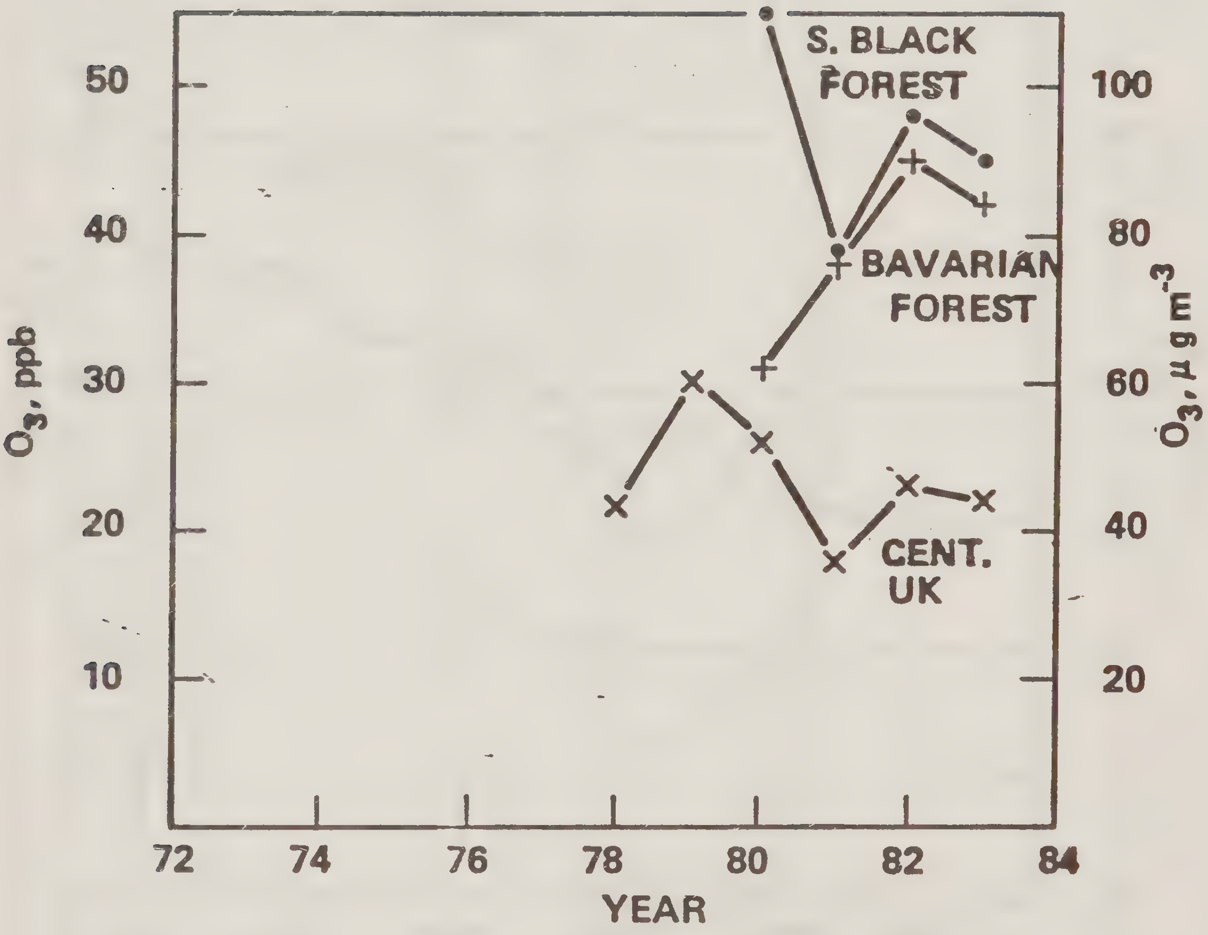
FIGURE 6


Exposure of plants to ambient ozone
Leaching of nutrients by acid rain/fog
Nutrient deficiency
Increased photosensitivity
Reduction of chlorophyll (yellowing of needles)
Reduced assimilation
Reduced root growth; root injury
Reduced uptake of nutrients from soil

OZONE/ACID MIST HYPOTHESIS

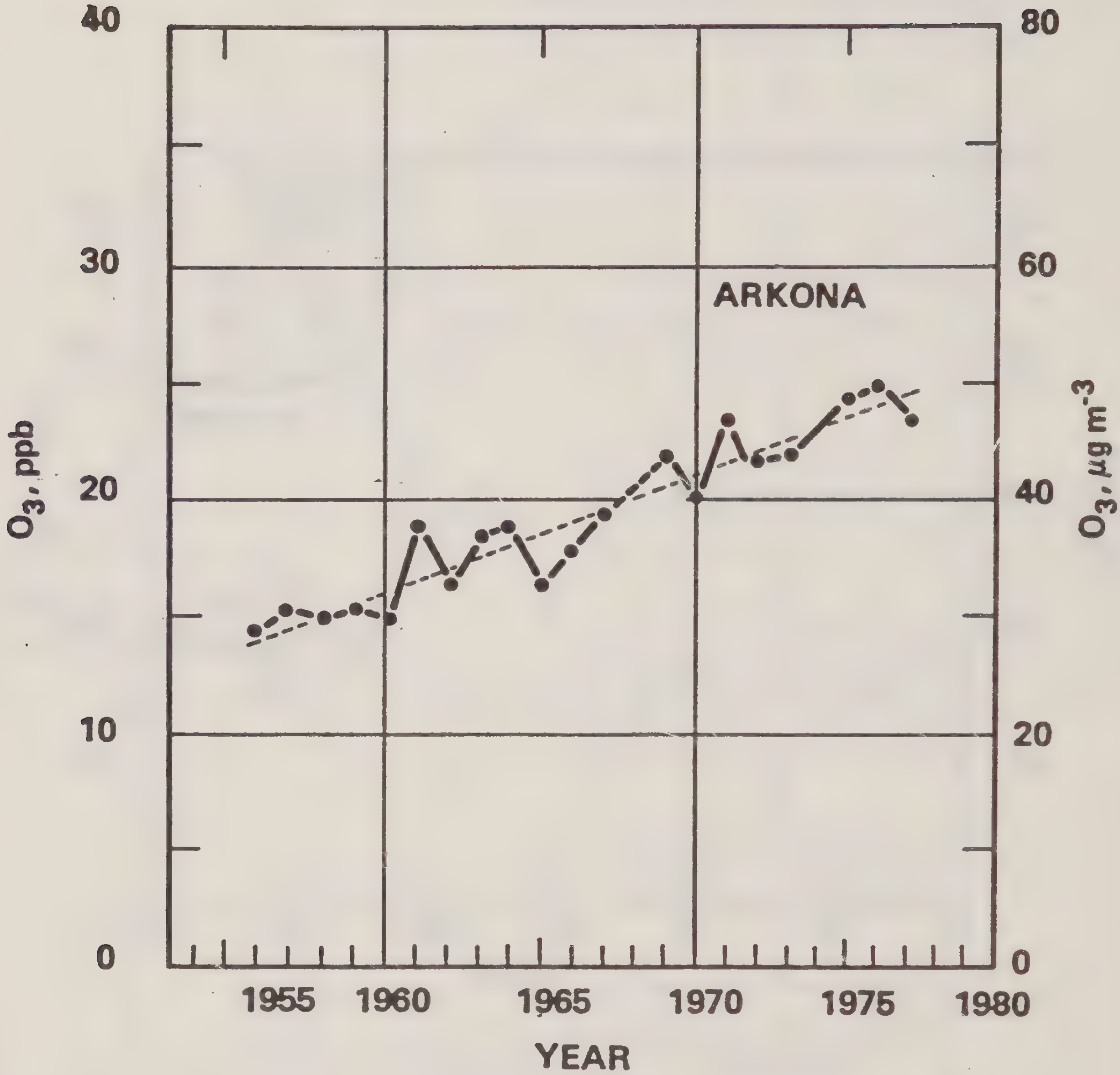
Possible Mechanisms for the Combined Effects of Ozone and Acid Mist on Tree Growth (after Prinz et al., 1982).

FIGURE 7



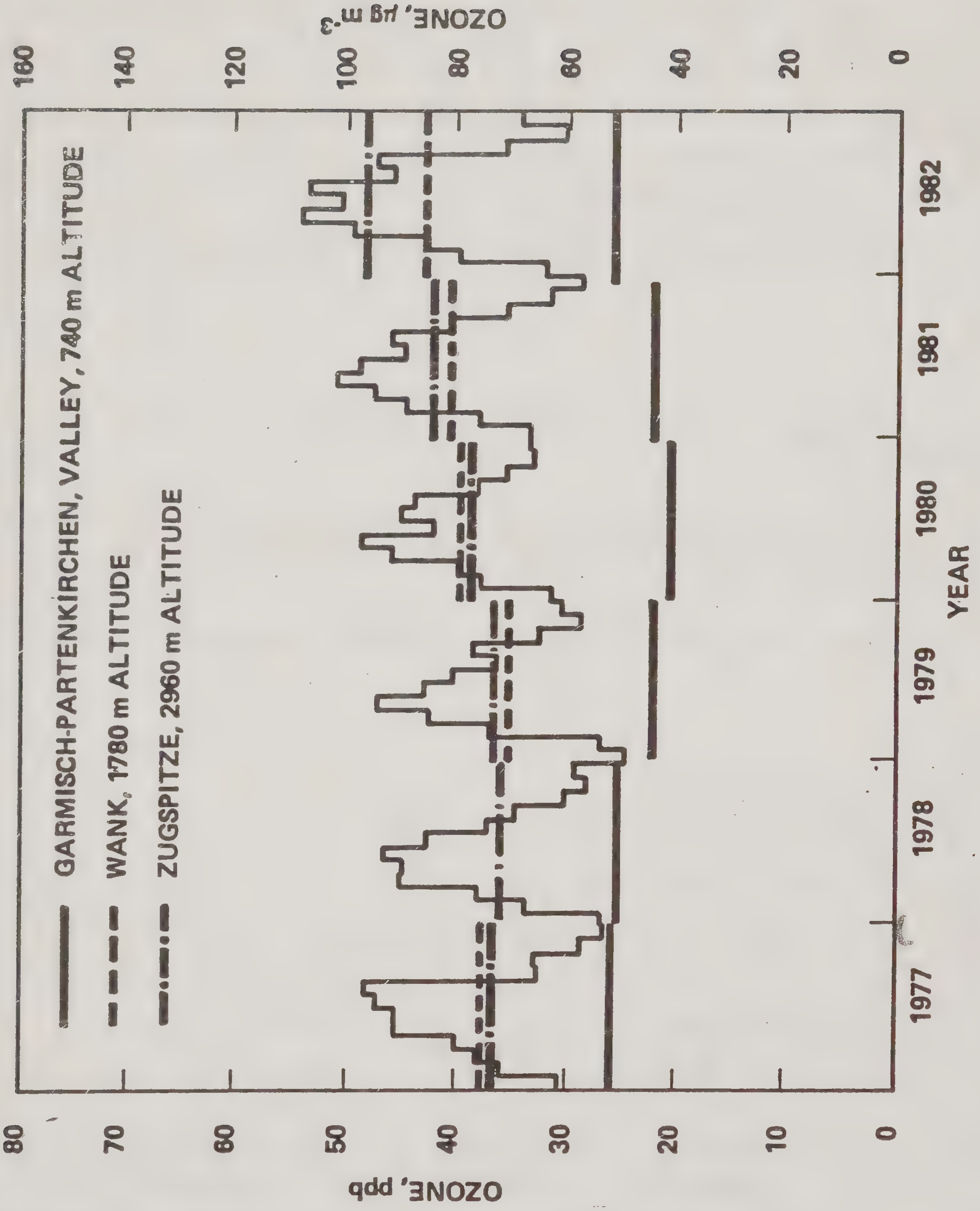
Mean annual concentration of Ozone in the Black Forest (Schauinsland), the Bavarian Forest (Brotjackriegel) (UBA, 1984) and Central UK (Bottesford) (Martin and Barber, 1981; 1984 and Martin, pers. comm.).

FIGURE 8



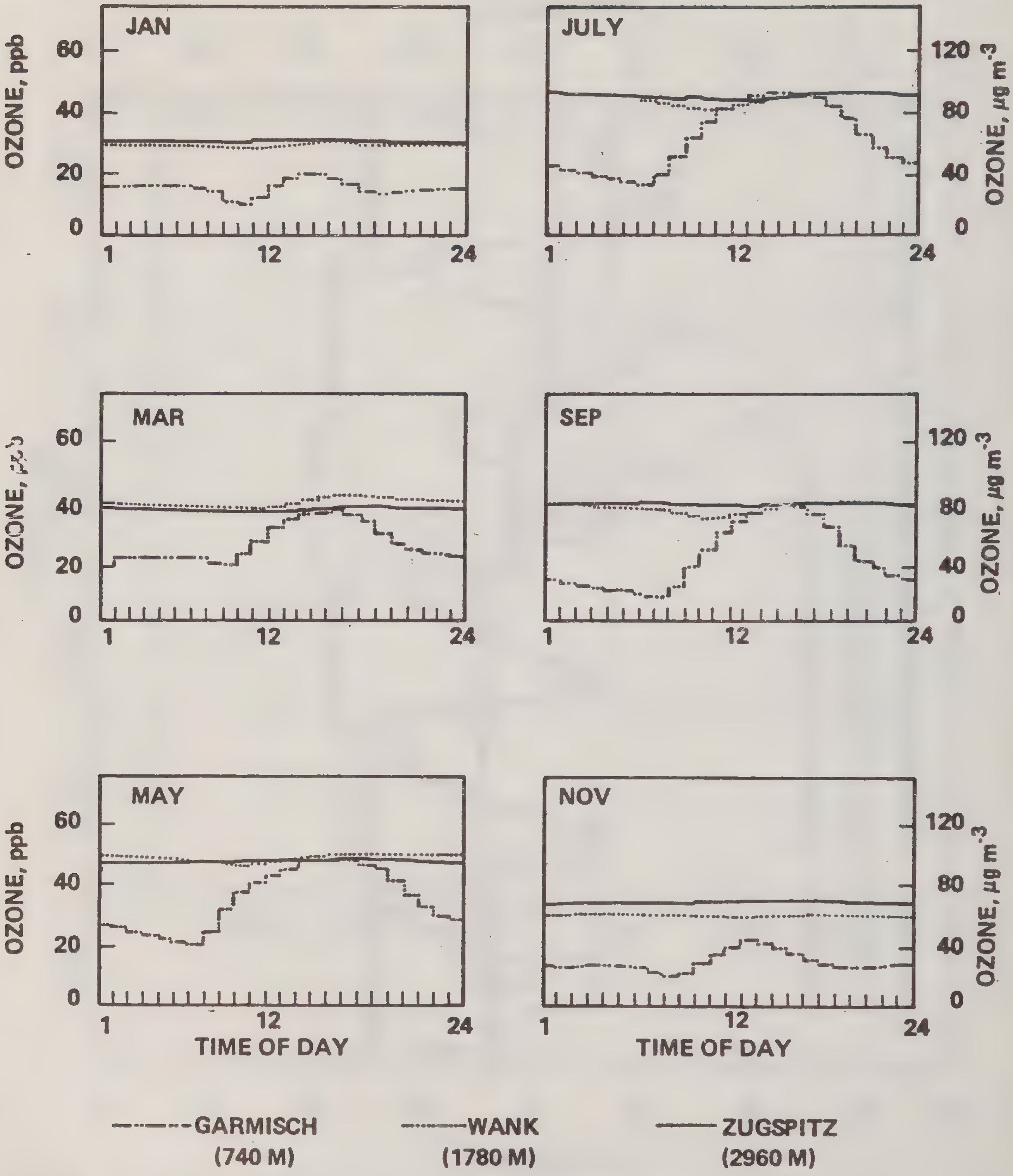
Trends in mean annual concentration of ozone in East Germany (Warmbt, 1978). (Ozone was measured by bubbling air through KI solutions so the data represents total oxidant. A filter was added in 1972 to remove interference from reducing gases such as SO_2.)

FIGURE 9



Trends in mean annual ozone concentrations at three altitudes in the Garmisch-Partenkirchen Valley in the Bavarian Alps. The pattern of monthly values is also shown for the site at Wank only (from Reiter, 1983) which is close to the tree-line.

FIGURE 10



Diurnal trends in ozone concentrations (1977-82) at three altitudes in the Garmisch-Partenkirchen Valley in the Bavarian Alps (Garmisch = 740 M; Wank = 1780 M and Zugspitze = 2960 M). The site at Wank is close to the tree-line.

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NOISE CONTROL OBJECTIVES IN TODAY'S SOCIETY

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1. WHY NOISE CONTROL?

The problem of noise pollution has been well recognised for at least 2,000 years. As early as 720 BC in the Italian city of Sybaris strict noise zoning laws were introduced in an attempt to improve the quality of urban life. In ancient Rome poets and writers complained of noise pollution from many sources, including street traders, town criers, schools, cattle and dogs. Indeed, Julius Caesar invoked noise control by means of strict laws and from then up to the present day many measures have been introduced to control this ubiquitous form of pollution.

It is therefore a matter both of surprise and regret that noise is still a problem which shows little sign of abatement either in the workplace or in society at large.

2. THE SIZE OF THE PROBLEM

2.1 Noise at Work

Some idea of the magnitude of the problem can be obtained by taking the countries of the European Economic Community (EEC) alone. Although in the year 1 AD Pliny the Elder expressed concern about the incidence of industrial hearing loss, a recent study by the Commission of the European Communities (Ref 1) suggests that there are still formidable numbers of workers in the EEC exposed to noise levels which are certainly undesirable and in many cases deafening:

dBA	Number exposed (estimated)
>80	20 - 30 million
>85	10 - 15 million
>90	6 - 8 million

2.2 Noise at Home

Unfortunately, having suffered the misery of undue noise at work, people do not necessarily find peace at home because they are frequently pursued there by the same pollutant! This disturbing noise may manifest itself as either single events or comparatively steady levels of din, each of which have their own particular way of annoying people. But absolute measurement of noise can be a difficult and complicated process, which makes it almost impossible to provide statistical evidence of the growth of noise in a typical densely populated country.

It is, however, possible to show the growth of the resultant problem in England and Wales by noting over a single decade the incidence of noise complaints received by Environmental Health Departments of local authorities:

2.3 Complaints received by Environmental Health Departments

(Noise complaints about ALL Sources per million persons)

'71	72	73	74	75	76	77	78	79	80	81
323	346	396	500	550	552	716	908	1115	1239	1307

Although part of this growth may well be due to improving methods of data collection, the increase in terms of apparent human misery is remarkable. Dramatic evidence of this is the rising tide of complaints against noisy neighbours whose subjective nuisance value can far outweigh the sound power which they generate.

2.4 Sources of Annoyance

Individual assessments of what constitutes noise nuisance are of course highly subjective and must therefore be regarded with due caution. But when recently the author canvassed through their Residents' Association the views of some 4000 people in a suburb of Bristol, the response produced the list shown in Appendix 1. As this list could be biased and is certainly not exhaustive, the reader may care to produce his own.

2.5 Outdoor Noise

Startling evidence of the widespread nature of outdoor din was given in 1980 at a conference on noise abatement policies (Ref 2). It was estimated that throughout the 12 countries comprising the Organisation for Economic Co-operation and Development (OECD), some one hundred million people were daily exposed to outdoor noise levels in excess of 65 dBA. In a city such as Paris almost half the population was thus exposed, and concern was expressed that hitherto quiet suburban and rural areas were being increasingly affected. There is as yet little evidence that those sentiments have been translated into effective noise abatement.

3. THE OBJECTIVE

The ultimate objective must be to reduce the level of unnecessary noise at work, at home, and in the community.

In the opinion of the author the NSCA finds itself in a unique position to do this and thus improve the quality of life for millions of people. In so doing it must be borne in mind that the problems arise more from the nature and incidence of particular noise sources than from the absolute sound energy emitted. It therefore follows that control is not solely dependent on silencing techniques and application of the laws of physics. In fact, success will depend on five separate factors which must be linked together into a continuous programme. They are:

Awareness and Consideration
Technical Factors
Cost Effective Application of Existing Knowledge
Legislation
Education

4. AWARENESS AND CONSIDERATION

It is inevitable that our daily activities produce certain noises which give us warning, information or simply pleasure; indeed, the complete absence of noise can lead to feelings of isolation or unease. Some degreee of noise is necessary to make the environment seem natural and for virtually every human activity there is an acceptable level of noise. So, between the producer and the recipient of the noise there should be engendered common feelings of awareness of the din (and possible annoyance) being produced and consideration of the other's need to freely pursue reasonable activities. There is much we can and must do to promote this degree of awareness and consideration, reminding everyone of their obligations as well as their rights.

5. TECHNICAL FACTORS

5.1 The Science of Acoustics

It is most unfortunate that what is arguably the commonest pollutant in society is bedevilled by a technical discipline in which the very language and terminology are so esoteric as to create a formidable barrier between specialists and laymen. The basic principles of noise generation, reduction and measurement are so well understood that it is almost criminal that they are currently so badly promulgated! Noise specialists have a duty to express themselves simply and clearly, in laymen's terms, so that problems (which are quite often too important to be left to the experts) can be understood and resolved by the public at large.

Being too technical can easily destroy the credibility of the acoustic scientist. A housewife who has complained of a particular noise problem is unlikely to be impressed by the scientist who after hours or weeks of measurement and analysis gravely pronounces that the lady indeed has the problem about which she originally complained! So it appears necessary to remind young acousticians that one's own ears are the most effective tool with which to identify and assess both noise problems and any measures taken to reduce or eliminate them. In spite of the well understood scientific principles, it is a fact that any discussion on the quest for silence is likely to be halted by pleas that finance be allocated for further research. We should consider whether the allocation of more research funds to quite mundane problems would simply grant us the joy of rediscovery.

But one topic which does require immediate scientific effort is the often ignored problem of low frequency emissions from both mobile and fixed plant.

5.2 Low Frequency Noise (Outdoors)

Low frequency airborne sound waves travel for considerable distances from source, and pass easily through most building structures. They also cause many people to feel annoyed, fatigued, wretched or ill. At frequencies around and above 40 cycles per second (40 Hz), they manifest themselves simply as low pitched sounds which, although not necessarily loud, are thoroughly unpleasant. Below 40 Hz the sound waves are likely to induce sympathetic vibration in buildings, fittings and furniture, which then gives rise to annoying rattling noises (Ref 3).

At present there is absolutely no legislative control of low frequency noise emissions, for surpriseingly all current regulations are framed in terms of the dB(A) unit which specifically excludes them!

The quality of life would be improved for many people if outdoor noise limits for both fixed and mobile plant were specified in terms of both dB(A) and the maximum permissible sound pressure in frequency bands below (say) 250 Hz. Until such controls are introduced, it will be impossible to eliminate the puzzling and annoying problem of noise-induced-vibration in buildings. Incidentally, the subjective annoyance is frequently exacerbated when the sufferer learns that the polluter is a statutory undertaking (such as a state railway) and therefore immune to most legal sanctions.

Sources to be dealt with include:

Mobile – Heavy transport such as ships, railway locomotives, lorries, buses and construction plant.

Fixed – Industrial boilers, compressors and large air-movers.

5.3 Low Frequency Noise (Indoors)

Guidelines must also be formulated to limit low frequency noise inside buildings. It is patently absurd that, regardless of any external noise, new buildings are commissioned to meet existing noise criteria but are then fitted out with heating, ventilating and other equipment which produces annoying or distressing low frequencies. When, as often happens, difficulties do arise, they tend to be ignored because there are neither adequate noise specifications nor the necessary awareness of the ill effects or the engineering remedies.

5.4 A Global View

In pursuing logical applications of existing knowledge, the acoustician must neither consider acoustics in isolation nor be mesmerised by the apparent simplicity of applying the rule: "always reduce the noise at source". Instead, he must take a broader view, conferring with other experts and with laymen to ensure that all relevant factors are taken into account. Nowhere is this more important than when seeking to control indoor pollution where there is a need to harmonise apparently conflicting needs for quietness, opennable windows, draught free ventilation, thermal insulation and humidity control, with aesthetics, economics and that most complex factor of all – human nature.

6. COST EFFECTIVE APPLICATION OF EXISTING KNOWLEDGE

In most cases knowledge of how to control particular sources of noise already exists, but there is all too often a lack of political, financial and managerial will to apply it.

To quote but a simple example:

6.1 Noise from the Roads

In a crowded country like the United Kingdom, noise from road transport is a major pollutant. Not only has the number of road vehicles increased, but freight vehicles have become heavier, more powerful and noisier. Surveys have shown that public reaction to traffic noise is weighted heavily against commercial vehicles. While 68% of people are annoyed on hearing unspecified traffic noise, 83% react to trucks and buses (Ref 4). Meanwhile the technology for silencing such vehicles already exists but is not being applied and on two counts manufacturers are being frustrated in their attempts to do so.

(a) Buyers are reluctant to pay the small increase in price incurred by fitting more than minimal silencing.

- As already demonstrated in certain European countries, this can be overcome by reducing the purchase tax on adequately silenced vehicles.

(b) An operator is unlikely to replace any silencing panel which he removes in order to gain access to the engine.

- An improperly maintained heavy vehicle represents both some danger to the public and waste of capital assets. Therefore, just as is already done with aircraft, planned maintenance and inspection procedures should be rigorously carried out. If this were so, the public would benefit from both reduced noise and smoke while the operator would achieve longer life and more efficient operation for the vehicle concerned.

Whatever the inherent noise of vehicles, local environments may be readily improved by simple, but well considered, traffic management schemes. Lorries, or indeed other noisy vehicles, may be diverted from a fairly quiet road on to an already busy highway. The noise increase on the busy road may well be negligible, while the quieter road may be improved to a very noticeable degree. But occupants of premises which flank the busy highway may well feel aggrieved because their (already high) noise exposure is being maintained in order to provide hush to others. Unfortunately, current regulations make no allowance for them to be compensated by the provision of sound insulation. Grants for this purpose are limited to cases in which either provision of a new road or physical alteration of an existing one causes the traffic noise to both increase and exceed a specified level.

Obviously control of noise from the roads would greatly benefit today's society but suitable choices must be made to fully exploit the possibilities of vehicle silencing, traffic management, urban planning and insulation of buildings in order to ensure cost effective environmental protection.

6.2 Cost-effective Prediction

In order for noise control to be achieved through legislation, planning or education, there must be improved dialogue between the acousticians and the politicians. The human and legislative aspects of noise control are open to argument and debate but the final decision on what is to be done is, in the broadest sense, always political.

Although the scientists may have their own technical differences, they must, before approaching the politicians, be absolutely sure of their facts. Many experts fail to recognise that in giving his backing or allocating funds to a particular policy, the politician is putting his reputation and arguably his career at stake. If a programme does not produce the predicted results or some reasonable progress before the next election, he may find himself in an invidious position.

In the United States of America, public funds were allocated in recent years to various environmental control programmes which did fail to fulfil the promises made by the acousticians. It will now arguably be a quarter of a century before the Administration is likely to further allocate substantial funds for similar activities. But the average Environmental Health Officer in this country seems to do it better. Even on problems over which he has no direct control, he presents complex technical data and faithfully reports the opposing views so that politicians can decide on cost-effective action. It would be well for the acousticians to learn these techniques.

7. LEGISLATION

In an ideal world people who were aware that they were causing undue noise would either desist or abate the nuisance. But in real life most people will only do that which is to either their own financial or political advantage, while there is inevitably a (mercifully smaller) number who will always put private gain before public benefit.

It is therefore imperative that types of noise which must be controlled for the public benefit be covered by legislation which is seen to be reasonable and equitable. In order that any financial burden resulting from legislation is equitably borne, it would seem but just to apply the accepted principle that "the polluter pays". Obviously the most cost-effective application of this principle is obtained by international control of noise at source. As such control should not be made unnecessarily restrictive it must take account of elements such as the time-block concept of differential noise limits for day time, night time, Sundays and that often ignored period of public intolerance to noise - the evening.

Enforcement of the law should not only be a policing activity but must involve pre-emptive action before noise sources are either installed or introduced.

However, control by this means will never be effective until we can demonstrate improved co-operation between the planners, the developers and environmental health officials.

8. EDUCATION

It is essential that the public is better informed on noise problems; what can and must be done; the rights and (more importantly) the obligations of the individual.

As the introduction of both new legislation and new technology tends to take several years, a long term educational programme started now could change the attitudes of younger members of society at a very opportune time. Any such programme must be sustained until the norm has been permanently changed, for the evidence is that short term campaigns (such as Quiet Town experiments) have not shown long term benefit to society at large.

9. ROLES

Five linked approaches to tackling the problem have been identified. There are complementary and equally important roles to be played by specialists, politicians and laymen alike. But the essence of success is, simply, communication.

9.1 The Acoustic Specialists

The experts will always be eager to demonstrate their knowledge and skill in the theory and application of acoustics. In order to maintain the highest possible standards, they will naturally involve themselves in arcane dialogue within their own visible and invisible colleges (Fig 1). But, to ensure, that their art is properly applied, they must express themselves clearly enough to communicate with laymen, and be humble enough to recognise that acoustics is not the hub of the universe. Indeed, it has been said (Ref 5) that experts must show that they are "technically competent, economically convincing, ecologically sensitive, environmentally literate and politically adept".

9.2 The Politicians

The polticians must:

- define those aspects of the noise problem to be controlled for the benefit of the public;
- formulate noise control policy after due consideration with laymen and experts alike;
- allocate the funds which are necessary for environmental control;
- effect legislation which accurately reflects the aspirations of society;
- ensure that the law is rigorously and uniformly enforced.

9.3 The Layman

Recognising that it is his world and he pays for it, the layman must make his voice heard by experts and politicians alike.

9.4 The National Society for Clean Air

The obvious body to bring together laymen, experts and politicians is the National Society for Clean Air which already has both long experience and a proven track record in pollution control. It is now time for the Society to extend that activity into the field of noise control at both national and international levels.

10. AN ACTION PLAN FOR THE NATIONAL SOCIETY FOR CLEAN AIR

10.1 National Activity

Building on its established position the Society should:

- bring together interested parties;
- provide a focus for advice/action on noise issues;
- collect and correlate relevant data;
- analyse and debate technical, humanitarian and political aspects of the noise problem;

- formulate "balanced views" on noise issues;
- promote Public Education in Noise;
- promote necessary research;
- act as the pressure group on noise control policy.

The Society's Council has already taken the first step by establishing (August 1984) a Noise Committee whose membership reflects the truly multidisciplinary approach of the Society to all pollution issues. Council will direct and guide this Committee's work, but some topics which may be worthy of consideration and action are shown in Appendix II.

As the programme gains momentum, Council may care to consider whether the present title of the Society accurately conveys to the public an image of its involvement in noise control.

10.2 International Activity

As a major British multidisciplinary body, the Society must actively participate in international control (Fig 1). Through the International Association Against Noise (AICB), it can contribute to the vital task of securing uniform standards between nations. Until such standards are evolved, industrialists in different countries will quite understandably fear that in trying to be good neighbours they find themselves financially penalised and thus rendered uncompetitive. The trend has been set, however, in such schemes as International Noise Certification of Aircraft and European Economic Community Directives on vehicle noise emission.

Note:

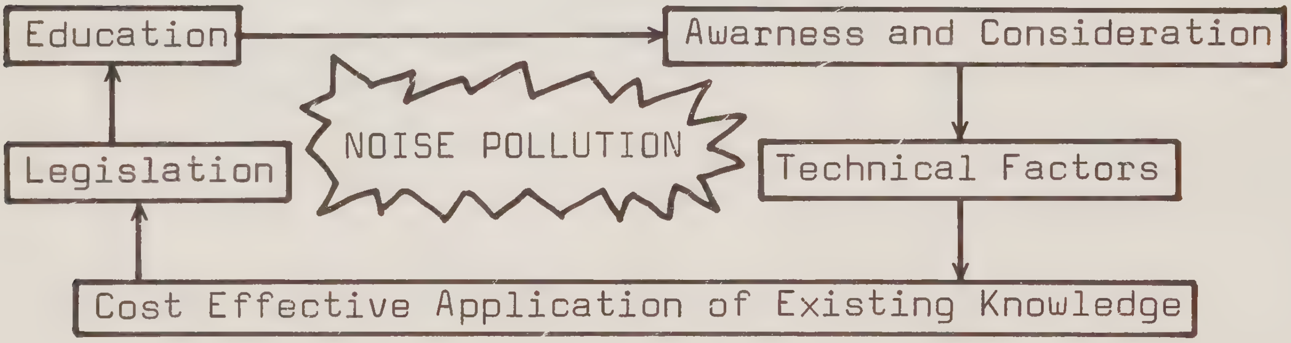
When, on behalf of the Society, the author recently attended the 13th Conference of the International Association Against Noise (AICB) (Ref 6), it became apparent that:

(a) too much effort is being dissipated in either preaching to the converted or to those who do not heed. Therefore, both national and international communication between the experts themselves and between experts and laymen needs some refinement. A suggestion for an 'ideal' communication chain is set out in Fig 1;

(b) the AICB consider that the NSCA can make a major contribution to international activity and would warmly welcome their fuller involvement.

11. THE OBJECTIVE SOCIETY

It is evident that to deal with the noise problem, standards and control objectives must be, as far as possible, supra-national and that each country must consistently strive to achieve them. But in order to gain access to scarce and variable resources, noise control must necessarily vie with other, equally important, environmental topics. Here the NSCA can play its vital co-ordinating role and can show those concerned how to use the five factors to construct a chain of activities whose size, power and resource can be continuously adjusted to match the circumstances of the day, viz:


Education
Awarness and Consideration
NOISE POLLUTION
Legislation
Technical Factors
Cost Effective Application of Existing Knowledge

Thence, following the precepts already laid down by Council and reinforced by the support of this Conference, the National Society can with confidence set out to shackle the ancient, ubiquitous and distressing problem of noise pollution.

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APPENDIX 1

SOURCES OF ANNOYANCE

Unranked sample of noise sources given as causes of substantial annoyance by Residents of a Typical Suburb (population 4000)

- Motor Cycles
- Barking Dogs
- Low Flying Aircraft
- Model Aircraft
- Hover Mowing Machines
- Traffic Noise generally
- Heavy Lorries in particular
- Express Trains
- Low Frequency Noise from:
  - Traffic
  - Boilers (domestic and industrial)
  - Ventilation/Heating Systems
  - Distant Discos
- Chain Saws
- Other power-drive Do-it-Yourself items:
  - drills
  - sanders etc.
- Late Night parties
- Late Night parties breaking up
- Stereophonic Systems (record players)
- Microlight Aircraft

APPENDIX II

SOME NOISE TOPICS WHICH MERIT CONSIDERATION
(Not in order of priority)

Future Development of Noise Indices

There is a case for some development of noise indices to cover:
- sound frequencies below 250 Hz
- time-block-corrected equivalent noise levels - Leq.

Existing Noise Regulations

There is a need for uniform and widespread enforcement of all existing noise regulations.

Low Frequency Noise

Noise criteria are required in order to define limiting sound pressures in (say) octave bands between 2 Hz and 250 Hz when measured
- at a given distance from source
- outside the nearest house
- inside any occupied living or working space

Noise Insulation Regulations

It would be desirable to grant compensation to those affected by increased traffic flow resulting from traffic management schemes which have not involved road alteration.

Transport Noise
- Road Rail and Waterborne Vehicles

Tighter noise control is needed for:
motor cycles - which tend to head any householder's nuisance list
heavy transport - to curb both din and low frequency emissions

Air Transport in Inner Cities

Controls should be applied to ensure that by means of engineering, town planning and architectural layout, society can enjoy the benefits of inner city airports and acceptable living conditions.

Noise in Buildings

Regulations should be tightened to enforce improved sound insulation between adjacent houses or flats.

Noise Rating

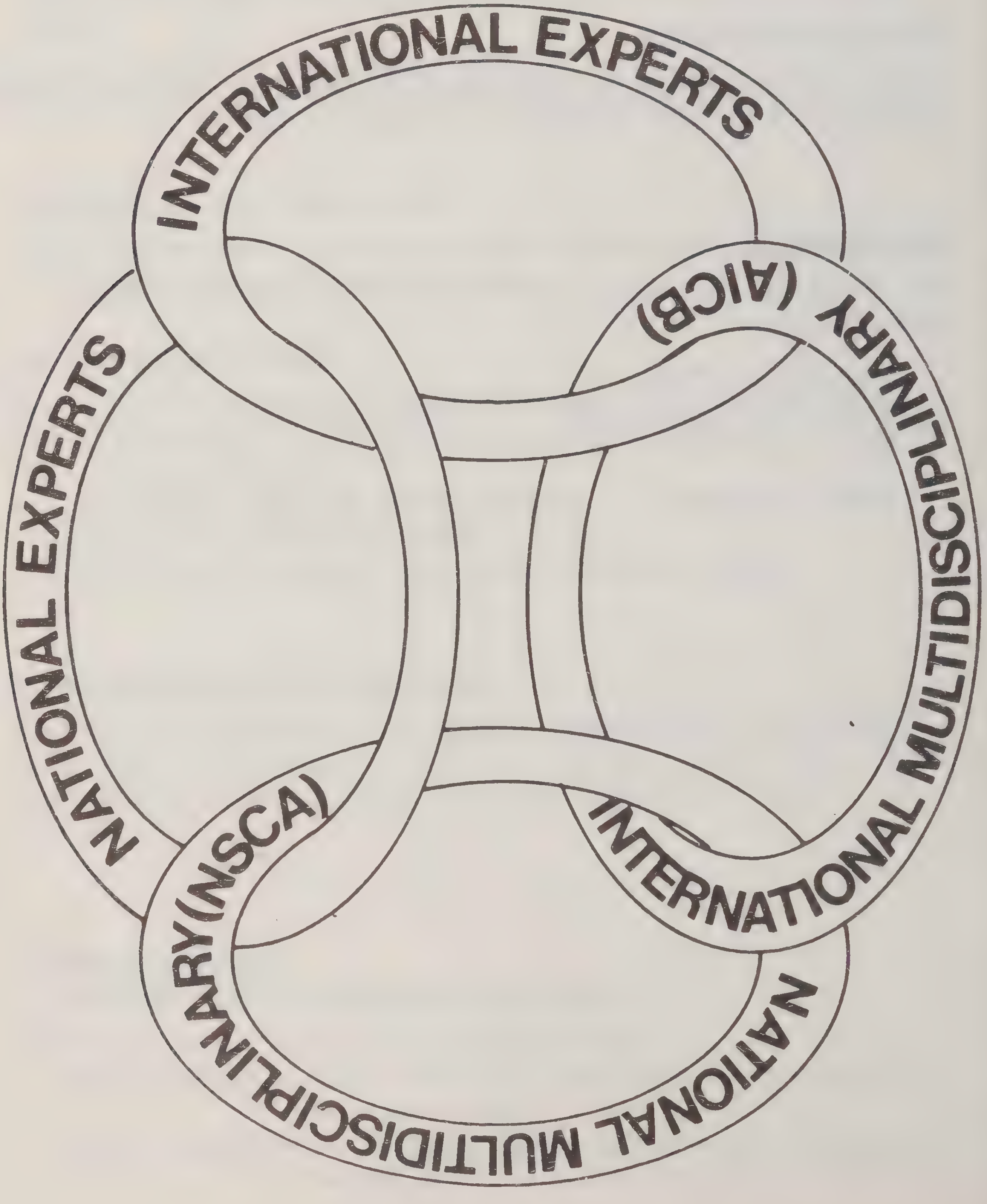
It would be desirable to allocate and publish noise ratings for:

Industrial Plant)
Domestic Appliances) to limit din
Do-it-Yourself Tools)

Hotel Bedrooms - as a comfort index

TO SHACKLE NOISE

An ideal communication chain for national & international activity


INTERNATIONAL EXPERTS
INTERNATIONAL MULTIDISCIPLINARY (AICB)
NATIONAL EXPERTS
NATIONAL MULTIDISCIPLINARY (NSCA)

nsca

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INDOOR NOISE CONTROL TECHNIQUES

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INTRODUCTION

Indoors, the noise environment is affected both by noise sources outside the building, e.g. traffic, aircraft and industrial noise, and by noise generated from within the building. Clearly, the most desirable treatment for controlling any noise is by reduction at source but this is often not possible, at least in the short term. Effective control can be achieved by using noise barriers and/or double windows for external sources but the solutions are more difficult when the noise is generated from within the building because of the interdependence of the source with the building structure.

There are two main types of noise within a building that have to be considered: noise from mechanical equipment, and noise from the everyday use of the building. In many cases, it is the lack of attention to detail about the installation and location of permanent equipment such as boilers, pumps and extract fans which causes noise to be transmitted through the structure. This noise, despite at times being of low intensity, can cause very severe distress. Additionally, these items of equipment may serve many households and, therefore, be out of the control of the person suffering from the noise.

In the case of noise from speech, footsteps and domestic appliances - such as televisions, hi-fi and food mixers - it is the quality of the design of the structure that generally determines how much noise is transmitted.

Whenever a problem arises, the specific solution depends on the architecture of the building, the noise source, to some extent on the lifestyle of the occupants and many other factors. It is clearly beyond the scope of this paper to consider in detail the solutions to noise control within buildings in general, but many of the acoustic principles are common. One of the most common problems which arise is that of the party floor between dwellings failing to provide adequate sound insulation and possibly transmitting noise due to the movement of furniture or people in the room above. It is intended, therefore, to concentrate on this problem, in particular, as it applies to rehabilitated dwellings. Many of the principles described here apply when solving other indoor noise problems, although of course some of the details will be different. The technical difficulties with rehabilitated dwellings also give rise to a legislative problem which is considered.

BACKGROUND

The conversion of Victorian houses into flats has been encouraged by recent housing Acts as a means of upgrading inner city areas without the upheaval of demolition and rebuilding[1]. Although the Acts lay down minimum standards for these conversions there is no mention of sound insulation. The Building Regulations 1976 Part G state that party floors should provide 'adequate' sound insulation but this part does not apply to conversions[2].

The existing floor between each storey of almost all converted houses is of the simple timber joist construction consisting of floor boards on joists with a lath and plaster or plasterboard ceiling (Figure 1). This construction forms a perfectly adequate partition between, say, a bedroom or a living room of a house occupied by one family. However, after conversion this floor becomes the party floor separating two independent households and it is desirable therefore that it should provide 'adequate' sound insulation. Unfortunately its sound insulation may fall well short of the standards given in the Building Regulations and it is often far from 'adequate'.

HOW SOUND INSULATION IS MEASURED AND RATED

In principle, measuring the sound insulation of a partition according to the relevant British Standard (BS 2750) involves recording the noise level in the rooms on either side of the partition when a sound source is operated in one of the rooms (the source room). A correction is made to the levels in the other (receiving) room to normalise the acoustic properties of that room to a standard value. The difference between the source room and receiving room levels is a measure of the sound insulation known as the standardised level difference.

As the standardised level difference of a partition varies with the frequency of the noise, this measurement is made over the frequency range of 100 Hz - 3150 Hz. The result gives an indication of the degree to which the noise from speech or music is attenuated by the partition and is known as the airborne sound insulation. In the case of floors, the ability to attenuate the noise arising from impacts, such as footfalls, also needs to be known. This is found by using a machine which produces a standard impact which approximately simulates footfalls in the upper room and measuring the noise generated in the room below over the same frequency range. The level is again corrected to give the impact noise transmission.

The Building Regulations describe how these results should be compared with standard performance criteria to arrive at a single figure value for both the airborne insulation and impact transmission called the Aggregate Adverse Deviation (AAD). The regulations define 'adequate' as an AAD of not more than 23 dB. A simple timber joist floor tends to give AADs well in excess of 100 dB. Some commonly used structures are "deemed to satisfy" the Regulations without recourse to acoustic testing but in practice insufficient attention to small details can lead to disappointing results.

METHODS OF IMPROVING THE SOUND INSULATION

Two designs involving a timber floor that should meet the requirements of the regulations are the floating floor with sand pugging which is the deemed-to-satisfy construction quoted in Schedule 12 to the Building Regulations (Figure 2); and the independent false ceiling with its two sets of joists (Figure 3). The independent ceiling is recommended by the Building Research Establishment as a means of improving the sound insulation in conversions[3]. Unfortunately it is not a straightforward matter to incorporate either of these designs in a conversion.

In most cases it is possible and consequently desirable to retain the existing joists and floorboards. The increase in mass resulting from the sand pugging would almost certainly be too great for the existing joists to support. While there is not a mass problem with the false ceiling design, installing a second set of joists may also not be possible due either to the limited room height available or due to the planning restrictions applying to the building.

The alternative design that has been investigated is a simple floating floor consisting of an upper surface (such as interlocking chipboard) loose laid on a resilient layer (fibre board or mineral wool quilt) which is laid onto the existing floorboards (Figure 4). The ideal combination consists of a top surface which is as heavy as possible but such that the elastic layer retains its resilience under load. This treatment means that the existing floor height is increased but usually to no more than 30 mm which would be allowable in most rooms. The floating element of the deemed-to-satisfy design is not suitable as it raises the floor height by 50 mm and the simple floating floor suggested by the Building Research Establishment[3] also suffers from increasing the floor height by 65 mm which architects also tend to regard as too much. 25-30 mm is really the limit.

CARE WITH DETAILS

Measurement of the simple floating floor has given a wide range of results and it has been realised that the degree of improvement depends on care and attention being paid to the details when installing this floor. Some important points are listed below:

1. Ensure that the top surface of the floating floor is not rigidly attached to the resilient layer.
2. Fix quadrant beading around the floor edge to seal any gaps.
3. Fix coving around the ceiling edges to seal any gaps.
4. Doors to common areas should be heavy and sealed well when shut.
5. Treat all the floor area removing fitted units if possible. Otherwise treat the floor up to the units and fill any holes in the floor within the units.
6. Fill any gaps around pipework that passes through the floor with tightly packed mineral wool or a wet filler.
7. Where services are in ducts ensure treatment extends through duct and clad duct with a layer of plasterboard.
8. On landing areas where the floor treatment cannot be used, fix a layer of hardboard to seal any gaps and use a rubber underlay in addition to carpet.
9. Leave the existing ceiling in place when fitting an independent ceiling.

PERFORMANCE

The best results obtained to date using the simple treatment of chipboard on fibreboard give AADs of 40 dB (airborne) and 34 dB (impact). Although still falling short of the Building Regulations standard this is a great improvement on the insulation provided by the simple timber joist floor.

It has been found that the independent ceiling usually gives AADs less than 23 dB although sometimes the impact performance is poorer. A floating floor and an independent ceiling have met the requirements of the regulations with an airborne AAD of 15 dB and an impact AAD of 21 dB.

COST

At 1983 prices the chipboard on fibreboard floating floor cost approximately £20/m^2. An independent ceiling costs approximately £30/m^2. Obviously the cost of the treatment depends very heavily on the precise site conditions.

IMPLEMENTATION - THE LEGISLATIVE PROBLEM

Having established that the existing floor in conversions will probably have very inadequate sound insulation and seeing that there are methods available to give a significant improvement in the performance, the problem of implementation then arises.

It has already been mentioned that the conversions are exempt from the requirements of part G of the Building Regulations which means that no developer has to improve the sound insulation. It is also highly unlikely that a developer will volunteer to carry out the extra work for, as yet, 'improved sound insulation' is not regarded as a good selling point. Consequently conversions are still completed with very poor sound insulation.

The lack of legislation is however understandable when considered from the legislators' point of view. Part G of the Building Regulations give constructions for new dwellings which if used are deemed to satisfy the Regulations and are expected to meet the performance standard of AADs less than 23 dB. (Although it is now being found that some of these designs in fact are not meeting the performance standard - but that is another problem.) Nevertheless it is possible to use one, if not all, of these designs in any new development. With the methods described earlier in conversions this is not so.

The designs that will probably meet the performance standard cannot be used in all circumstances, and the design that is 'universal' has yet to have a performance record that merits inclusion in part G. The pity is that it does not seem possible to amend the regulations so that they say that some treatment must be included, with it being left to the discretion of the building control officer/district surveyor to ensure the best possible one is used in a particular situation; and yet, to some extent, this is how local authorities are providing a solution to the problem.

With council owned properties a simple policy decision is enough to ensure that the floors are treated, and some local authorities have taken such action. Private sector development is also being controlled in some areas by use of the planning powers. Negotiations between the developer and usually the environmental health departments result in some treatment being used. This means that as long as the technical guidelines mentioned above are followed then a significant improvement in sound insulation is achieved. Although the performance standard of the Building Regulations may not always be met, an AAD of 34 dB is infinitely more desirable than an AAD in excess of 100 dB.

It is to be hoped that all local authorities will soon adopt this solution - but it can only be regarded as an interim measure. In the long term the solution is to find a reliable simple treatment that can be used in any situation. The commissioning of laboratory tests of various combinations of materials is one way in which this can be done and would certainly enable identification of those materials that are not suitable; but there is a great difference between what can be achieved in the laboratory and what is achieved on site, especially in converting old buildings. The problems of installation and how they can affect both the cost and sound insulation performance can only be identified by using the particular treatment in a real situation.

Now that some local authorities are ensuring that the floors are being treated it means that 'on-site' data are available. Any one authority though would have too little information for it to be possible to draw any significant conclusions; but the combined results from a number of authorities may be enough.

The Scientific Services Branch is therefore setting up a data bank to which the London Boroughs and any other interested local authority will be invited to contribute. If it is successful in attracting a large quantity of data then it will go some way towards identifying a treatment that could be included in the Regulations. As the local authorities can influence what treatment is used it should also be possible to obtain results from using a wide range of materials, obviously avoiding those which have been identified as totally unsuitable in laboratory tests.

Measurement of the acoustic properties of complete structures on site has the advantage that the quality control problems of the installation of the treatment are included. Effects of flanking transmission (which is sound that passes between the rooms via routes other than straight through the floor) are inherently included in the results. Although this can confuse the comparative assessment of various design options it is a practical installation problem which must not be ignored and is one of the additional difficulties in installation and quality control which in the laboratory may not be apparent.

CONCLUSION

The problem of providing adequate sound insulation can be largely overcome almost regardless of the various restrictions there may be such as: the state of the existing floor; the planning constraints; the available space and cost. More information is required on the performance in practice of various designs and to this end the Scientific Services Branch of the GLC is setting up a data bank to co-ordinate the data available to individual local authorities. It is hoped that the results from the data bank will enable a design to be developed which is easy to install and gives a reliably good sound insulation performance. If reliable designs can be identified, there will be no technical reason why conversions should remain exempt from the sound insulation requirements of the Building Regulations.

ACKNOWLEDGEMENT

The authors wish to thank the Head of the Scientific Services of the GLC for allowing this paper to be published. The views expressed here are those of the authors and not necessarily those of the GLC.

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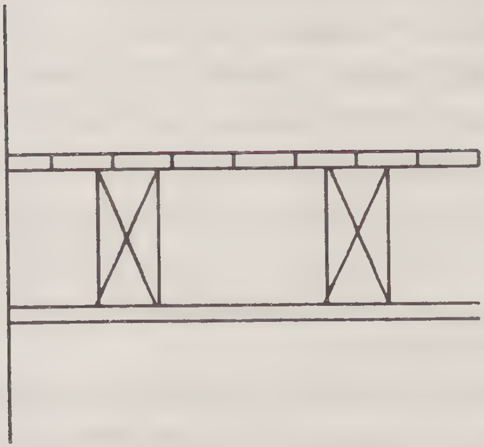

Fig 1 - Simple Timber Joist Floor

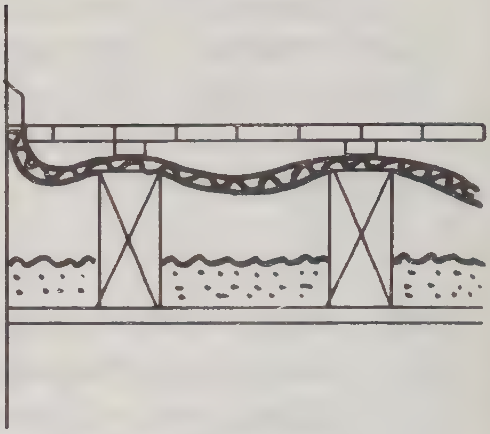

Fig 2 - "Deemed to Satisfy" construction from Building Regs.

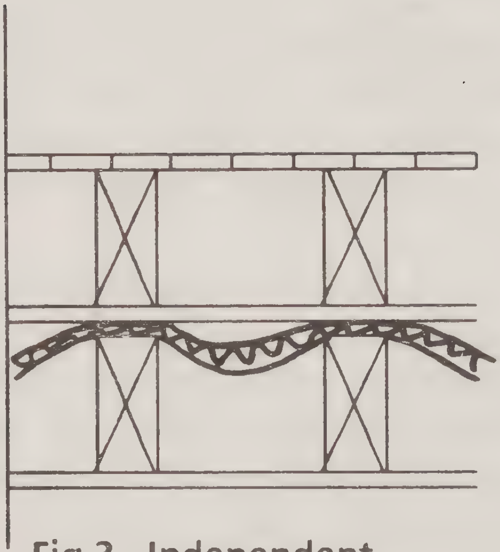

Fig 3 - Independent Ceiling Design

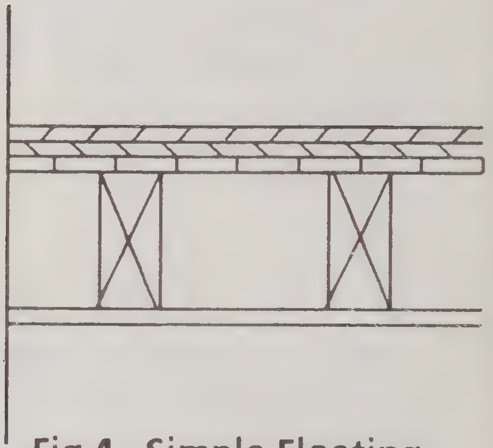

Fig 4 - Simple Floating Floor Design

nsca

51st ANNUAL CONFERENCE
1 – 4 OCTOBER 1984
BRIGHTON

LEGISLATIVE AND POLICY EFFECTS ON MOTOR VEHICLE DESIGN FOR NOISE AND EXHAUST EMISSION CONTROL

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INTRODUCTION

In this paper we propose to look at the ways in which legislation aimed at limiting the environmental impact of the motor vehicle has intentionally - and unintentionally - affected vehicle design, sometimes in ways adverse to both the consumer and the public at large.

It is true to say that measures to reduce the unwelcome effects of the motor vehicle on the environment are supported in principle by everyone, including the vehicle manufacturers, even though the main burden of satisfying those measures falls on those manufacturers. It must not be overlooked that we, of the motor industry, live here too - our professional burden does not immunise us from undesirable effects, but it does tend to sharpen our perceptions. We are, perhaps, more acutely aware of the balance of benefits/disbenefits that must be weighed in order to be clear on the value to society of any given control measure.

Hence our concern - sometimes seen as obstructiveness - that the public at large, and the consumer in particular, really do get effective, realistic controls, controls that they are prepared, and above all able, to pay for.

After all, if new, "environmentally-friendly" cars are too costly for the average family motorist to buy them, then older, less satisfactory vehicles will just be around longer ......

BACKGROUND

Let us first look briefly at the evolution of regulations limiting what we might call the "nuisance-factor" of the motor cars.

We can go back some 150 years to the steam driven road "locomotives" of the early 19th Century, when national regulations began to be introduced to control the construction and use of road vehicles, to combat emissions of "smoke, sparks or grit" and "excessive noise", among other things. These regulations were generally subjective; objective assessment methods for noise, smoke, etc., began to be incorporated generally into national regulations only around the middle of the present century.

As national preferences and priorities varied, so also did their construction and use requirements for motor vehicles, which threatened to inhibit the movement of vehicular traffic across national frontiers. To resolve this difficulty, the Geneva Conventions of 1926, 1949 and finally 1968 established minimum construction and use requirements for "vehicles in international circulation", that is, tourists (Fig 1).

These conventions, however, did not apply to permanently imported vehicles; in the late 1950s, therefore, the United Nations Economic Commission for Europe (UN/ECE) established the "1958 Geneva Agreement" which set up a process whereby internationally agreed construction requirements for motor vehicles and motor vehicle parts would be reciprocally recognised by participating countries. These countries became parties to the Agreement and adopted those individual Regulations on specific aspects of vehicle design which were acceptable to them.

The first of these Regulations affecting motor vehicle emissions - UN/ECE Regulation No. 9 concerning exterior Noise from motor vehicles - was established in March 1969; control of radio frequency emissions - UN/ECE Regulation No. 10, in April 1969; that for exhaust emissions from spark ignition engined vehicles - UN/ECE Regulation No. 15 - in August 1970, and UN/ECE Regulation No. 24, Diesel Smoke, in September 1972 (Fig 2).

Since these initial Regulations, and as motor vehicle design has progressed technically, the performance standards set have become progressively more demanding, and correspondingly more difficult to achieve, with paradoxically, progressively less benefit - the "law of diminishing returns".

For example, the passenger car's contribution to NOx - one of the two prime candidates for blame in the current "acid rain" debate - has been estimated for the UK at around 23%, whilst the theoretical NOx emissions from all sources, including power stations, plant decay etc., is estimated to account for some 30% of acid rain in the UK.

Thus the car's contribution to acid rain is of the order of 7% (30% x 23%) and even adding in the effects of diesel engined road vehicles, this rises only to around 9%. NB: Sulphur dioxide, or which the road vehicle content is negligible, forms some 70% of the total acid rain.

It will therefore be appreciated that a reduction of the passenger car's contribution, even to as low as half its present level, is a small 3.5% reduction in the total context (Fig 3).

PUBLIC AWARENESS

There is no doubt that a large part of the increasing pressure for action to protect the environment has come about as a result of increasing public awareness of the issues.

Public opinion is being more effectively marshalled by pressure groups concerned with the protection of our environment, and this trend is not lost on the lawmakers.

All too often this results in action whose primary function appears to be to satisfy the political need to be seen to be "doing something". Realistic evaluation of the potential effectiveness of the "something" is rarely feasible before implementation, and actual resulting benefits are difficult to identify and assess after implementation, particularly where exhaust emissions are concerned.

Taken together with the growing concern for the conservation of finite energy resources – oil – sparked off in the early 1970's when the major oil producing countries realised that they had the oil users literally "over a barrel", these pressures have led to intensified study and development of the internal combustion engine.

In the latter half of the 1970s first France, then the UK, followed subsequently by other countries, introduced legislation requiring the measurement and publicising of the fuel consumption of passenger cars.

Voluntary agreements between Governments and their domestic motor industries to improve the fuel economy of passenger cars – by 10% over 5 years – has been well exceeded; in 1983 the Society of Motor Manufacturers and Traders (SMMT) advised that the fuel economy target had been "passed two years early – plus 50 percent".

However, SMMT pointed out that this improvement had been achieved in spite of increased severity exhaust emission requirements introduced in the meantime; further strengthening of European Community exhaust emission requirements scheduled for 1985 will reduce future economy gains by some 2 to 2.5 percentage points.

It will therefore be appreciated that many other factors have to be considered by vehicle manufacturers if they are to satisfy consumers and stay in business (Fig 4).

The limiting of emissions of whatever sort has to be handled in the context of the total benefit expected.

Nonetheless, the need for limiting such emissions is a real one, but two questions have to be asked:

To what extent?

How much are you prepared to pay?

Remember, first cost is NEVER the whole story; costs have a nasty habit of coming back and biting the purchaser again, and again, by way of increased maintenance, replacement, and general operating costs.

OBJECTIVITY

In order to establish what must be done, it is necessary to be very clear on the nature of the problem.

To this end, measurement of air quality, its relationship to variations in perceived sources (traffic, stationary sources, natural sources), dispersion characteristics, consequential effects - all these, and other, aspects need to be at least recognised, and understood as far as possible, in order to ensure that the correct course of action is followed.

Again, the cost of whatever action is decided upon must be included in the evaluation of the benefit expected - and that expected benefit has to be a real-world benefit, not some "pie-in-the-sky" theoretical benefit that may never be realised or cannot be measured. Great care must therefore be taken in writing the regulations to ensure that the desired real-world effects really will be obtained.

Too harsh a set of conditions may well result in the engineers being forced to "design to pass the test".

PRACTICAL CONSIDERATIONS

Before moving to the meat of this matter - the direct effects on vehicle design - let us take a brief look at some practical aspects of legislation that need to be borne in mind.

First of all: does the technology exist and, preferably, has it been proven in service to do what is required? Many techniques evolved in experimental laboratories do not either lend themselves to adoption in mass production, or stand up to the rigours of use by the public at large (Fig 5).

Can the desired level of control really be translated into reliable, durable hardware? Or do the imposed "standards" effectively "legislate invention" as happened in the exhaust emission control field in the USA in the mid-1970's?

In addition to this, the effects of D.I.Y. engine repairs on exhaust emission controls, or radio frequency emissions, noise shields etc., must not be ignored.

Next we must bear in mind the capacity of the affected Administration to carry out its monitoring, or policing, function; the appropriate Government department(s) must be staffed by sufficient trained inspectors, backed by adequate workshop facilities to enable them to monitor conformity with the legislation.

Finally, that oft-recurring, disagreeable subject of cost. No manufacturer, nor Administration for that matter, has a bottomless pot of gold. ALL costs - both for making the vehicle, and for testing/approving it (i.e. the manufacturer's and the Government's) are paid by you, the consumer.

Your ability to pay for new, exotic technology - including periodic replacement or maintenance - has to be taken into account; it is all part of the balance that needs to be kept between the desirable and the feasible, the necessary and the ideal. The cleanest, quietest road vehicle in the world is of no use if few people can afford to buy it, run it, or use it.

In the end, this all adds up to COMPROMISE.

Just what that means in practical terms we shall see now.

COMPROMISE

If we analyse the means whereby emissions from a motor vehicle are reduced, it becomes apparent that there are two main routes:

- Don't generate it.
- Don't let it get out.

Let us look at these in more detail - first for the reduction of the amount of noise generated:

Noise sources are, briefly:

- The engine - both from the firing impulses via the resonance of the engine components, and from the exhaust gases as they vent to atmosphere.
- Mechanical - again, two main sources - engine components, transmissions etc. - and general "clatter" from body, chassis, hood etc.
- Tyres - the noise from vehicle tyres is greatly affected by tread pattern and even more by the road surface, with speed, load and number of wheels also being significant.
- Wind noise - the much-in-vogue "aerodynamic" effects.

Techniques such as strategically located ribbing on cylinder block and gear box castings (to reduce resonance at normal engine speeds), attention to power-pack mountings, use of higher capacity, more carefully tuned, exhaust systems, etc., can have quite a significant effect on reducing the generation of noise - up to a point (Fig 6).

Beyond this, rather cruder techniques are necessary - noise barriers, shielding, even total engine encapsulation (Fig 7), (Fig 8).

All these add cost. Most add weight. Some bring further complications such as the need for higher capacity cooling systems, or revised engine power characteristics (Fig 9).

So, to reduce exterior noise, we add control systems, which add weight, and increase demands on the cooling system which in turn must have increased capacity; thus load capacity is reduced, so engine power is increased to compensate, which means more fuel consumption, but also stronger transmissions, and so on, and so on.

So we have a truck - or a car - which is quieter, albeit heavier, less economical, with a more powerful engine.

But, and this is a factor which must be weighed - does it retain that "quieter" characteristic throughout its working life? Or does routine maintenance gradually degrade the effectiveness of the sound shielding etc. - or perhaps result in it being left off altogether?

To introduce in-use regulations to cope with this possibility implies periodic measurement of noise emissions in use (or a detailed knowledge of the specification of every truck/car on the road!).

Let us leave our heavier, less economical, more powerful, but quieter truck for the moment and have a look at the exhaust emissions aspect.

Here again, the two-route analysis applies:

- Don't generate emissions.
- Don't let them escape, uncleansed, into the environment.

Taking the second of these first, various techniques have been evolved to reduce the emission of undesirable products of combustion: closed crankcase ventilation systems; exhaust after-burning; catalytic converters, etc. The control systems, and the technology, become more complex, more precisely tuned to the test procedure as legislated emission levels are made ever more stringent.

Such techniques inevitably affect the operation of the vehicle, its performance, its fuel consumption, its driveability. They may also demand specific engine operating conditions in order to be effective. For example, early exhaust emission control systems using after-burning techniques required rich mixtures to be supplied by the induction system so that combustion continued in the exhaust system with the help of air pumped in. The purpose was to ensure that exhaust carbon monoxide and hydrocarbons were satisfactorily oxidised.

This was not very fuel efficient.

Similarly, the adoption (in the USA) of three-way catalyst systems (Fig 10) requiring air/fuel mixture ratios close to a chemically balanced situation - "stoichiometric" - also acts as an inhibition; catalyst systems are complex in themselves (Fig 11); they require complex control technology and skilled use of expensive equipment to ensure their continued effectiveness (Fig 12), care in fuel and vehicle use, and regular skilled maintenance, which may be beyond the capability of the third, fourth or fifth owners. Trends in engine design in Europe in recent years, however, have been towards ever "leaner" operation in the interests of fuel economy, spurred on by the oil crises of the 70s.

In a paper prepared for a conference in 1983, the British Government's Warren Spring Laboratory in Stevenage reviewed a number of alternative approaches to exhaust emission control; their potential for emission reduction, fuel consumption changes and cost effects were tabulated. Extracts from that table show the relative merits of the major possibilities considered (Fig 13). Which brings us back to the more desirable alternative of the "don't generate it" route.

The aim here is to construct the engine and its combustion chamber, and control the combustion process, in such a way that the presence of undesirable components in the exhaust gases - CO, HC and NOx - is minimised, whilst at the same time improving its economy, reducing the noise generated, and developing adequate power. The technique is known as 'HCLB' - High Compression Lean Burn (Fig 14). Development of engines operating at these leaner air/fuel ratios, much leaner than stoichiometric, has reached the point where they are beginning to find their way into production (Fig 15). Examples are Ford's 1100 Fiesta and 1.6 E-max Sierra, Volkswagon's new Golf, Jaguar's revised V12.

Offering petrol economy improvements of up to 20% over current (1983) engines, this route has the capability in the future to reduce NOx by 80% from the uncontrolled situation, and approximately 90% for CO. Thus the "best of both worlds" appears possible. The "prove-out" process has begun - as noted, we at Ford have two vehicles in production now with the fore-runner of the 'HCLB' - the "fast-burn".

CONTEXT

It must be borne in mind that however necessary the control of motor vehicle emissions and noise may be - and no-one would deny the necessity - there are other considerations, such as safety, cost, reliability, that also have to be balanced.

There are many major legislative requirements affecting, for example, truck construction (Fig 16). None of these can be handled in isolation - all have some interaction on the others. As we have seen, there is a "knock-on" effect such that a solution in one area raises a new task in another.

Only so much work can be done with given resources - there is a balance to be struck between what can be done, and how soon (Fig 17). As time to implement new requirements is curtailed so the technical resources that must be used to do the engineering must be increased, and the greater the pressure on resources, the higher the cost of meeting the requirements.

Inevitably, if too much of a manufacturer's engineering capacity is applied to one objective, other, perhaps equally desirable, objectives may have to be abandoned, or at least postponed.

The gestation period for a major new design - engine or vehicle - is some 60 months. Many different disciplines are involved: finance, design, test, tooling, manufacturing, marketing (Fig 18).

At the end of the day, the product has to be the right specification for its intended market, available at the right time, at the right price, and has to satisfy environmental and energy concerns and be attractive to the consumer.

CONCLUSION

Requirements must be so framed that they do not prevent innovation; they must not present unrealistic or arbitrary standards.

Ideally, vehicle construction and use requirements must be based on:

- Proven priority need
- Co-ordinated program of consultation/introduction
- Wide discussion with affected parties
- Technical feasibility - don't "legislate invention"
- Performance based requirements
- Cost-effectiveness
- Realistic timing vis-a-vis industry's resources
- Precise compliance: objective assessment necessary
- Enforceability by Administrations
- Pre-emption by Internationally agreed equivalents
- Amendment after wide use.

It is essential that, if we are to meet the sometimes conflicting demands of care for the environment and consumer preferences within a framework of regulations governing the use and the construction of vehicles, then those regulations must be thoroughly "thought through", their provisions must be both achievable and necessary, their implementation must realistically recognise the limitations on Industry's resources, and their costs must be such that you, the customer, consumer, taxpayer, voter, are able and willing to accept them. Otherwise, older, less environmentally-friendly vehicles will remain in use longer, to the detriment of us all.

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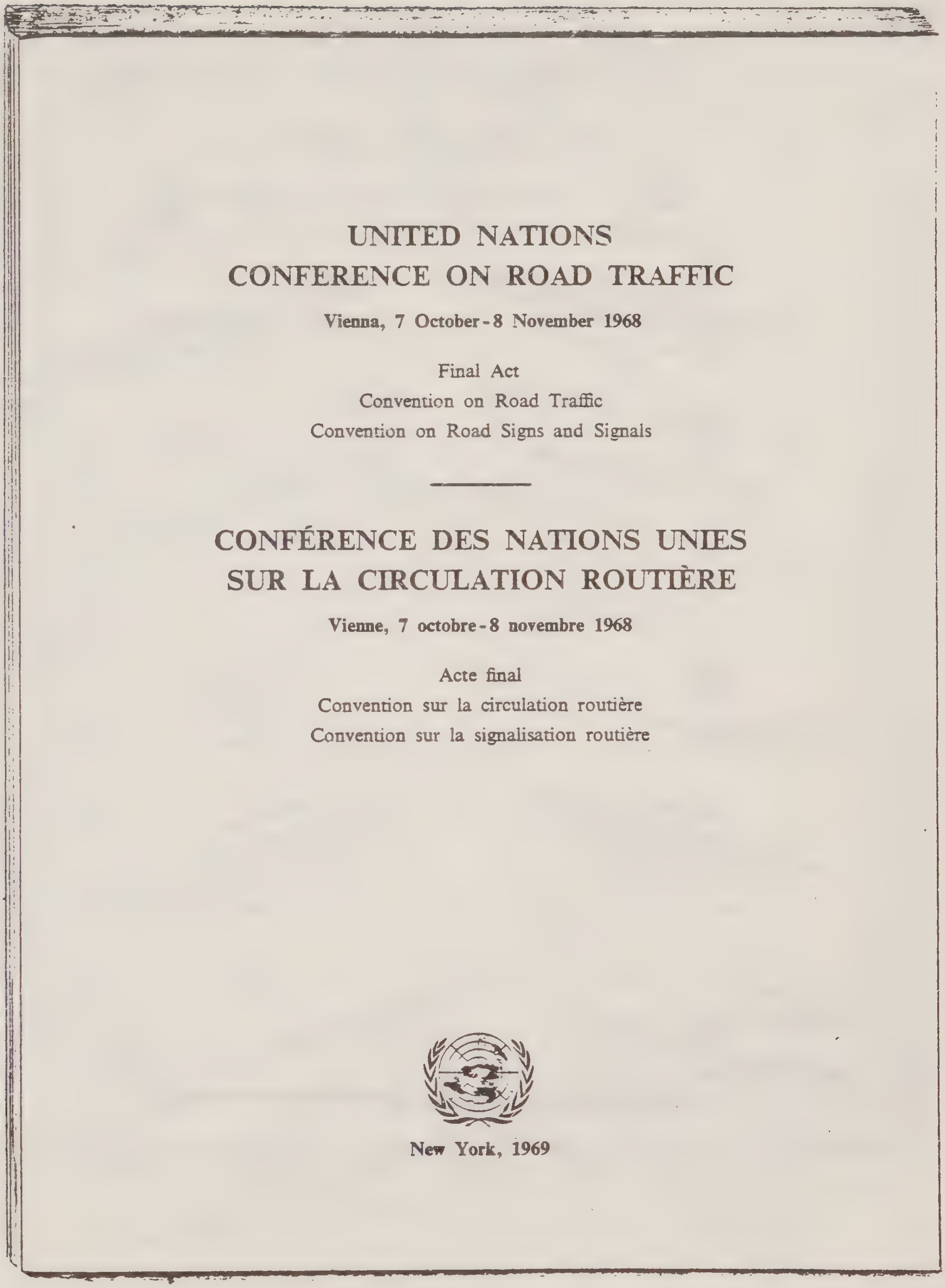
fig 1



UNITED NATIONS
CONFERENCE ON ROAD TRAFFIC

Vienna, 7 October-8 November 1968

Final Act
Convention on Road Traffic
Convention on Road Signs and Signals

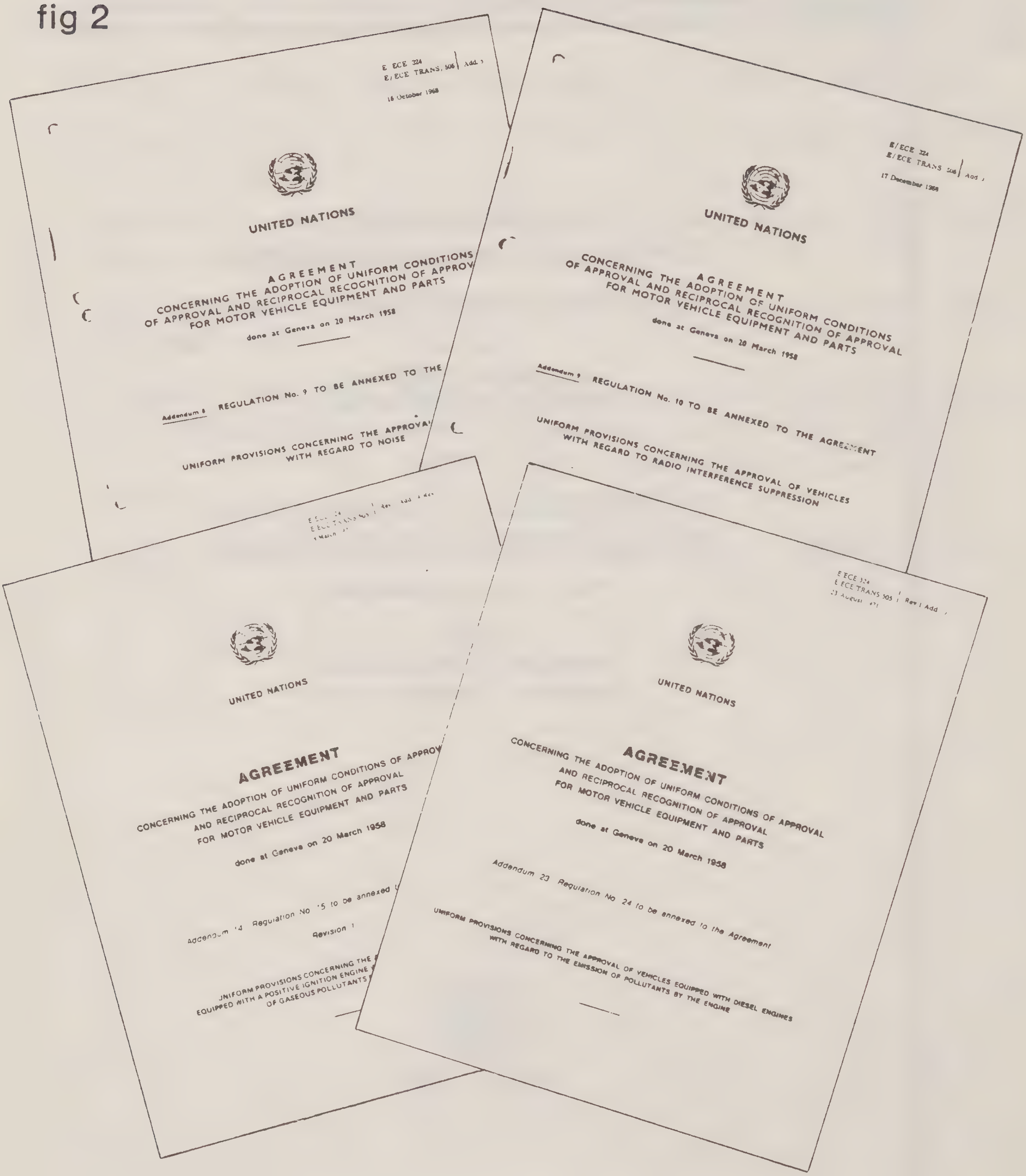
CONFÉRENCE DES NATIONS UNIES
SUR LA CIRCULATION ROUTIÈRE

Vienne, 7 octobre-8 novembre 1968

Acte final
Convention sur la circulation routière
Convention sur la signalisation routière

New York, 1969

fig 2



E/ECE 324
E/ECE TRANS/506 | Add. 8

16 October 1968

UNITED NATIONS

AGREEMENT
CONCERNING THE ADOPTION OF UNIFORM CONDITIONS
OF APPROVAL AND RECIPROCAL RECOGNITION OF APPROV
FOR MOTOR VEHICLE EQUIPMENT AND PARTS

done at Geneva on 20 March 1958

Addendum 8 REGULATION No. 9 TO BE ANNEXED TO THE

UNIFORM PROVISIONS CONCERNING THE APPROVA
WITH REGARD TO NOISE

E/ECE 324
E/ECE TRANS 506 | Add. 9

17 December 1968

UNITED NATIONS

AGREEMENT
CONCERNING THE ADOPTION OF UNIFORM CONDITIONS
OF APPROVAL AND RECIPROCAL RECOGNITION OF APPROVAL
FOR MOTOR VEHICLE EQUIPMENT AND PARTS

done at Geneva on 20 March 1958

Addendum 9 REGULATION No. 10 TO BE ANNEXED TO THE AGREEMENT

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES
WITH REGARD TO RADIO INTERFERENCE SUPPRESSION

UNITED NATIONS

AGREEMENT
CONCERNING THE ADOPTION OF UNIFORM CONDITIONS OF APPROV
AND RECIPROCAL RECOGNITION OF APPROVAL
FOR MOTOR VEHICLE EQUIPMENT AND PARTS

done at Geneva on 20 March 1958

Addendum 14 Regulation No 15 to be annexed

Revision 1

UNIFORM PROVISIONS CONCERNING THE
EQUIPPED WITH A POSITIVE IGNITION ENGINE
OF GASEOUS POLLUTANTS

E/ECE 324
E/ECE TRANS 505 | Rev.1/Add.

UNITED NATIONS

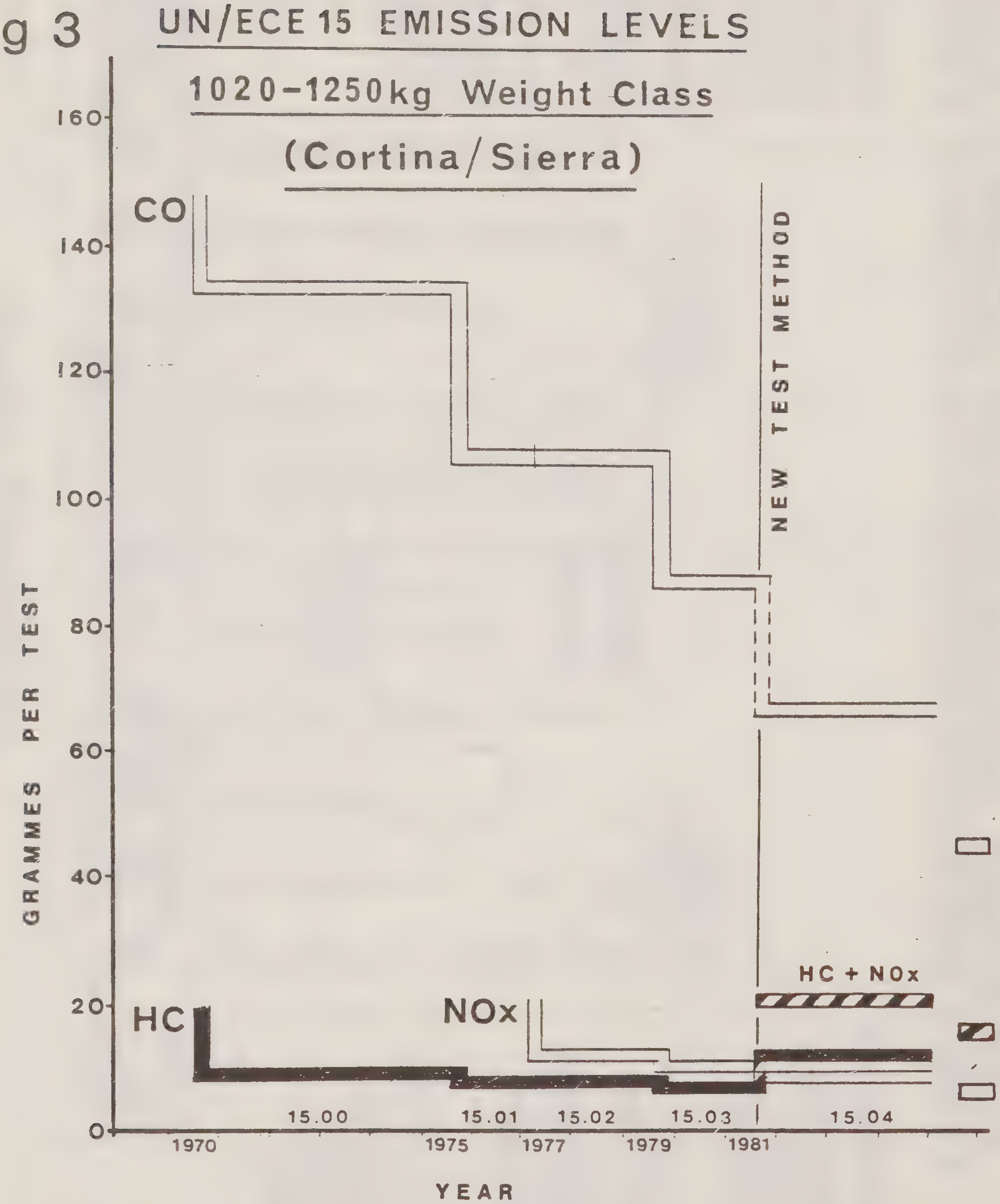
AGREEMENT
CONCERNING THE ADOPTION OF UNIFORM CONDITIONS OF APPROVAL
AND RECIPROCAL RECOGNITION OF APPROVAL
FOR MOTOR VEHICLE EQUIPMENT AND PARTS

done at Geneva on 20 March 1958

Addendum 23 Regulation No. 24 to be annexed to the Agreement

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES EQUIPPED WITH DIESEL ENGINES
WITH REGARD TO THE EMISSION OF POLLUTANTS BY THE ENGINE

fig 3



UN/ECE 15 EMISSION LEVELS

1020-1250kg Weight Class

(Cortina/Sierra)

fig 4 FACTORS INFLUENCING VEHICLE DESIGN

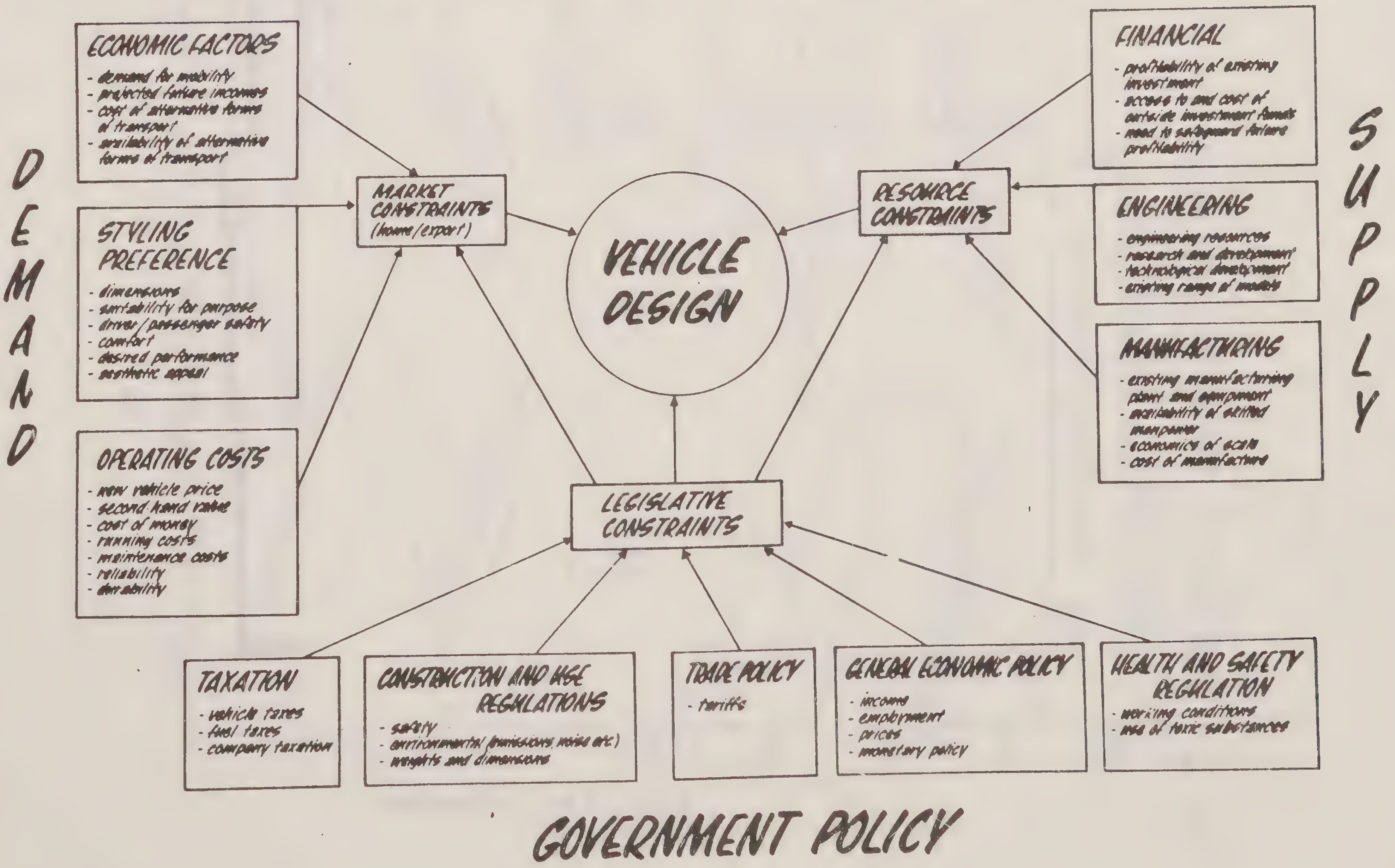
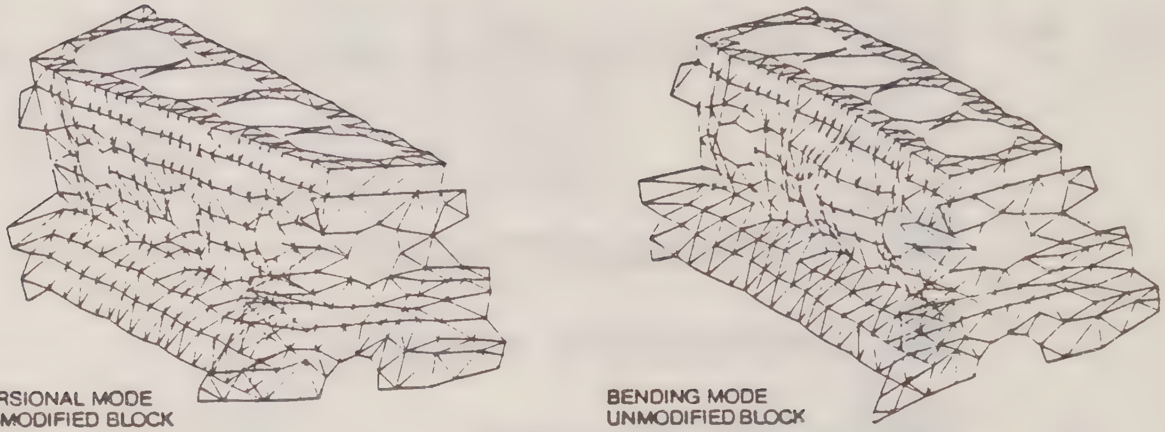


fig 5 IDEAL TECHNICAL C&U LAWS ARE BASED ON

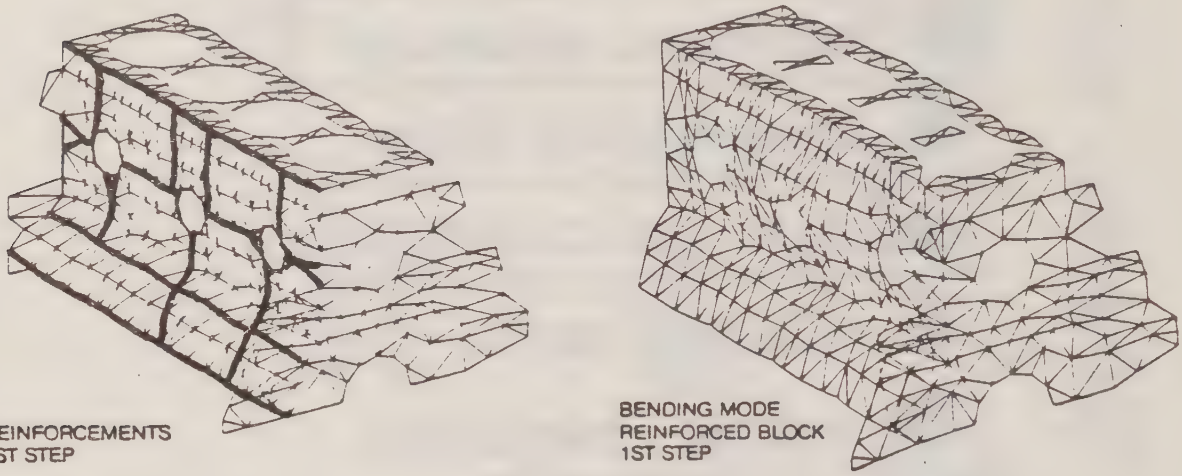
- PROVEN PRIORITY NEED
- COORDINATED PROGRAM
- WIDE DISCUSSION
- TECHNICAL FEASIBILITY
- PERFORMANCE REQTS
- COST-EFFECTIVENESS
- REALISTIC TIMING
- PRECISE COMPLIANCE
- ENFORCIBILITY
- INTERNATIONAL PRE-EMPTION
- AMENDMENT AFTER WIDE USE

fig 6 **CVH ENGINE BLOCK SIMULATION**



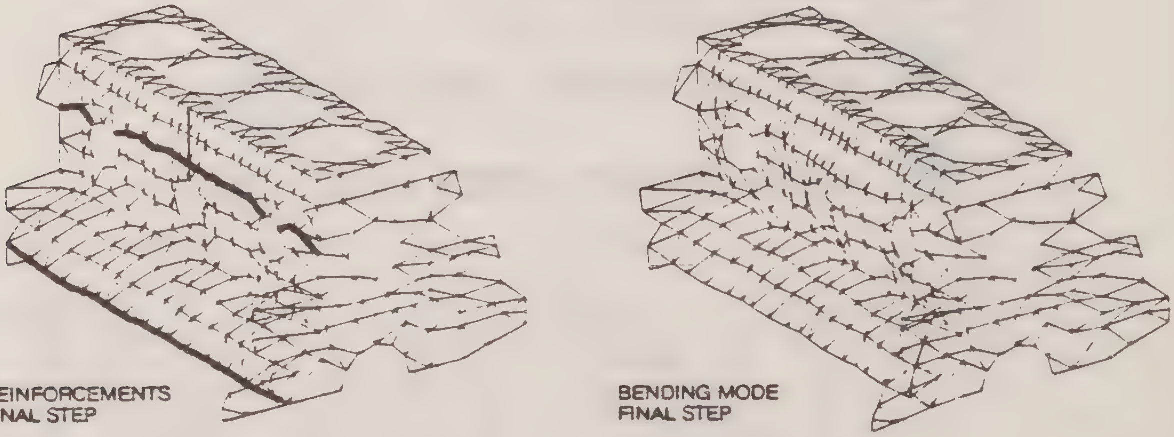
TORSIONAL MODE
UNMODIFIED BLOCK

BENDING MODE
UNMODIFIED BLOCK



REINFORCEMENTS
1ST STEP

BENDING MODE
REINFORCED BLOCK
1ST STEP



REINFORCEMENTS
FINAL STEP

BENDING MODE
FINAL STEP

REDUCTION OF VIBRATION BY ADDITION OF MINIMUM STIFFENING.

SOURCE: FORD ENERGY REPORT. VOL. 2. 1981

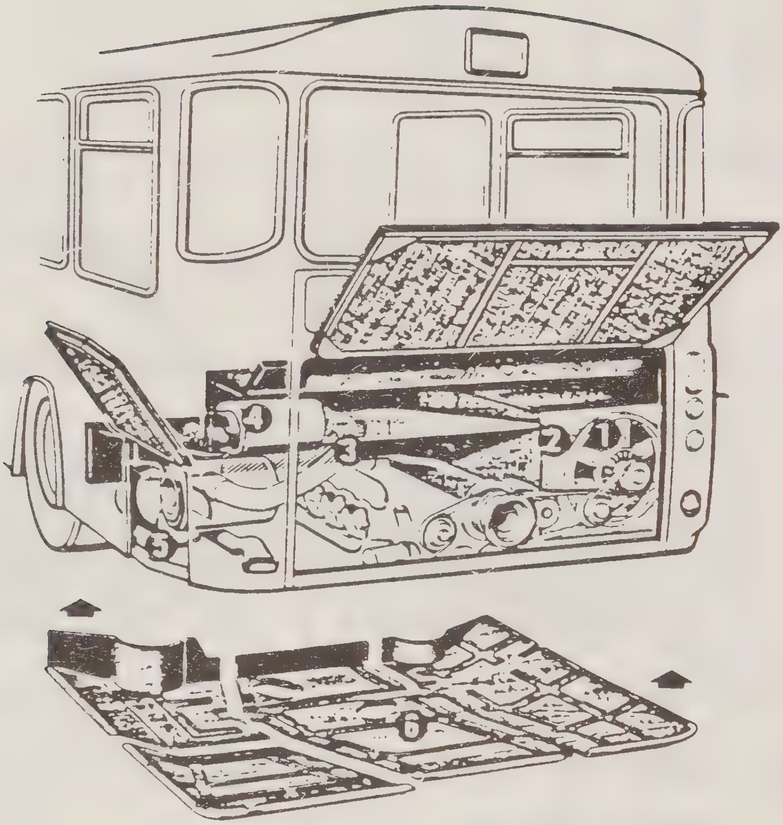


fig 7 ENGINE COMPARTMENT INSULATION IN A STANDARD CITY BUS IN SCHEDULED SERVICE

SOURCE: "URBAN TRAFFIC AND NOISE", VDA, 1978

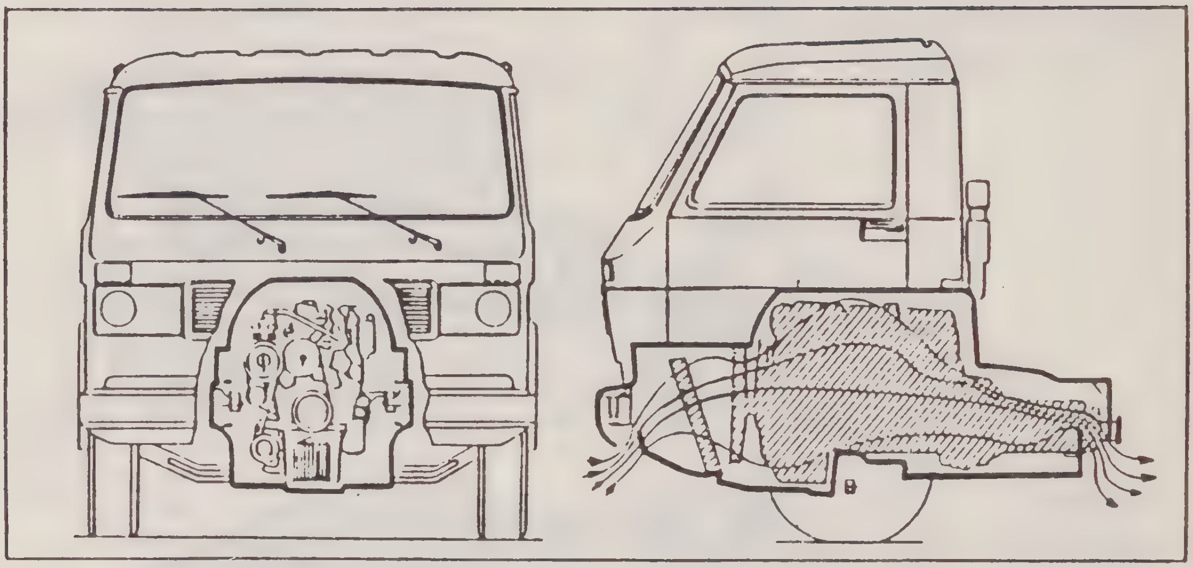


fig 8 ENGINE AND GEARBOX ENCAPSULATION IN MAN-VW MT RANGE

SOURCE: MAN-VW

fig 9 OBJECTIVE : REDUCE EXTERIOR NOISE

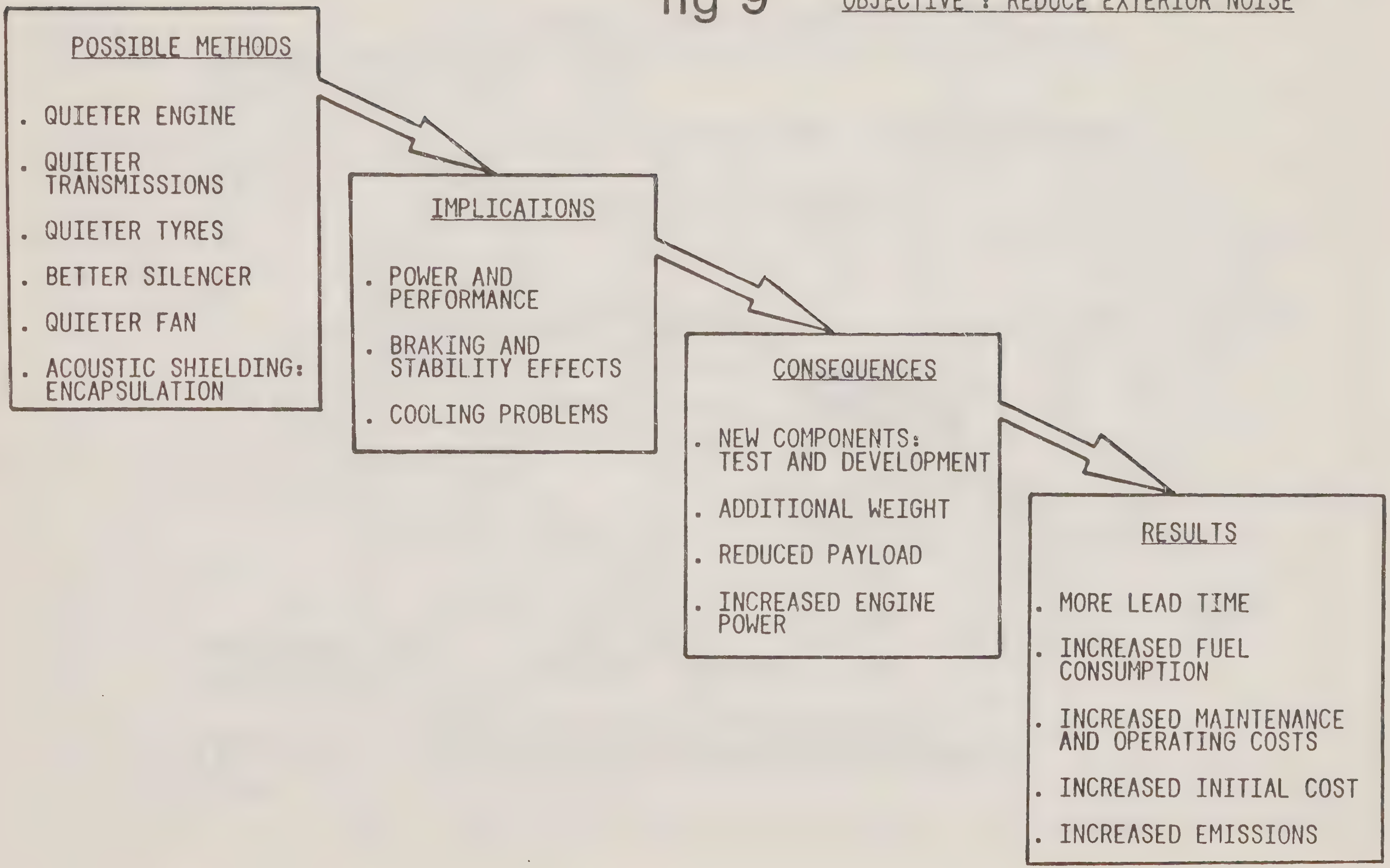


fig 10 ENGINE EQUIPPED WITH U.S. FEDERAL EXHAUST EMISSION CONTROL SYSTEM - AS INSTALLED INTO CHASSIS

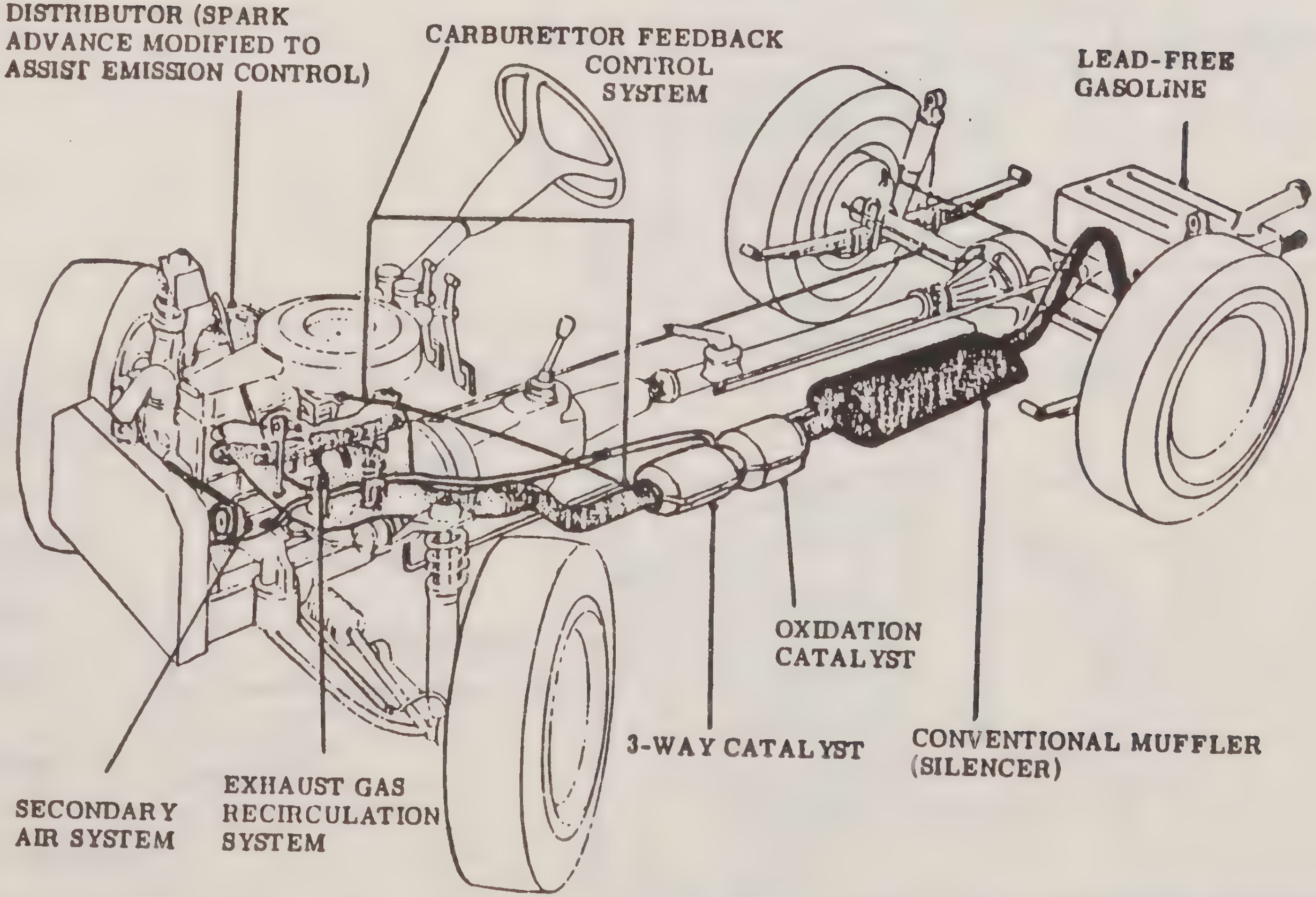
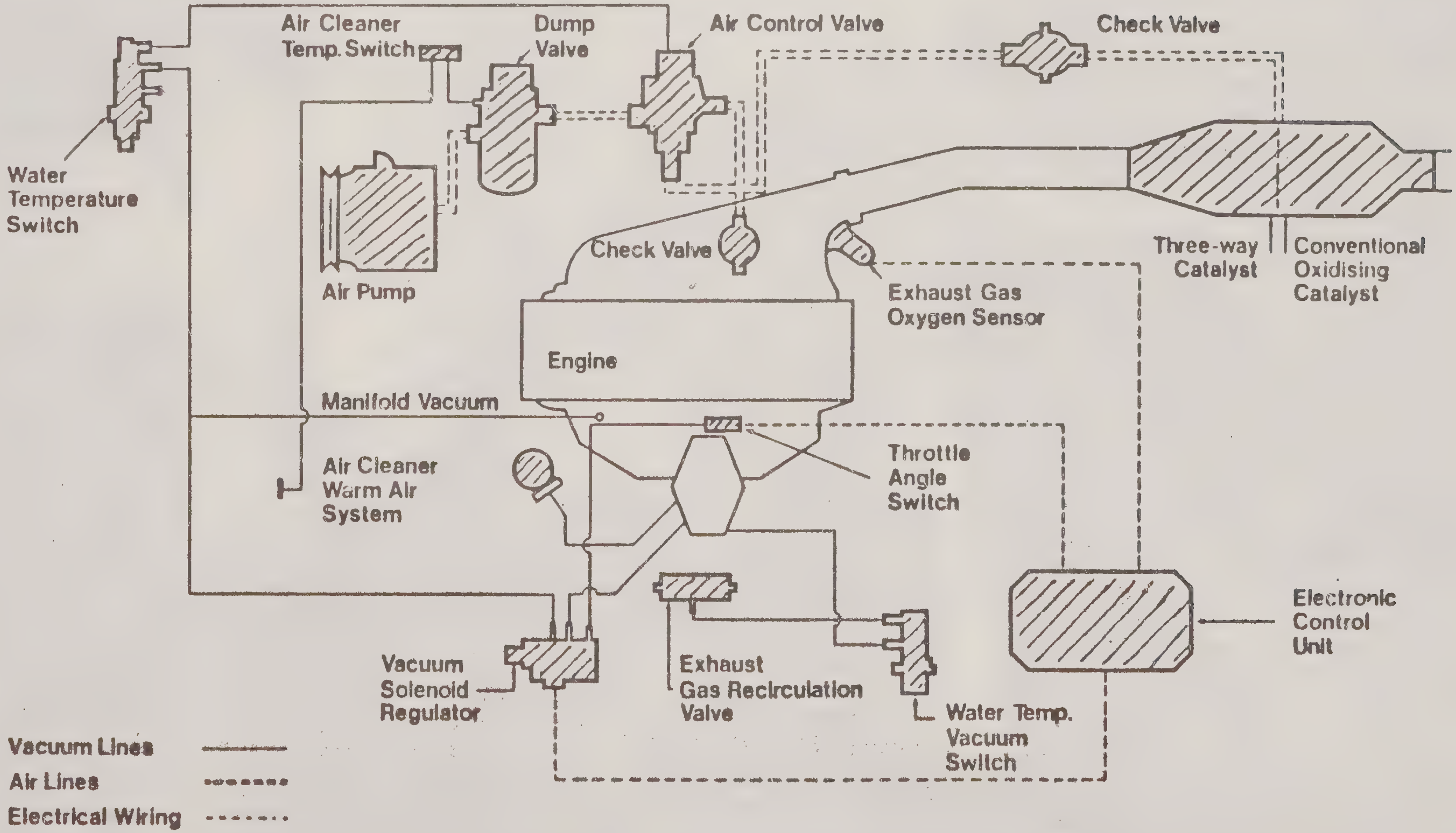

DISTRIBUTOR (SPARK ADVANCE MODIFIED TO ASSIST EMISSION CONTROL)
CARBURETTOR FEEDBACK CONTROL SYSTEM
LEAD-FREE GASOLINE
OXIDATION CATALYST
3-WAY CATALYST
CONVENTIONAL MUFFLER (SILENCER)
SECONDARY AIR SYSTEM
EXHAUST GAS RECIRCULATION SYSTEM

fig 11 TYPICAL EXHAUST EMISSION CONTROL SYSTEM TO MEET CURRENT U.S. FEDERAL EMISSION REQUIREMENTS



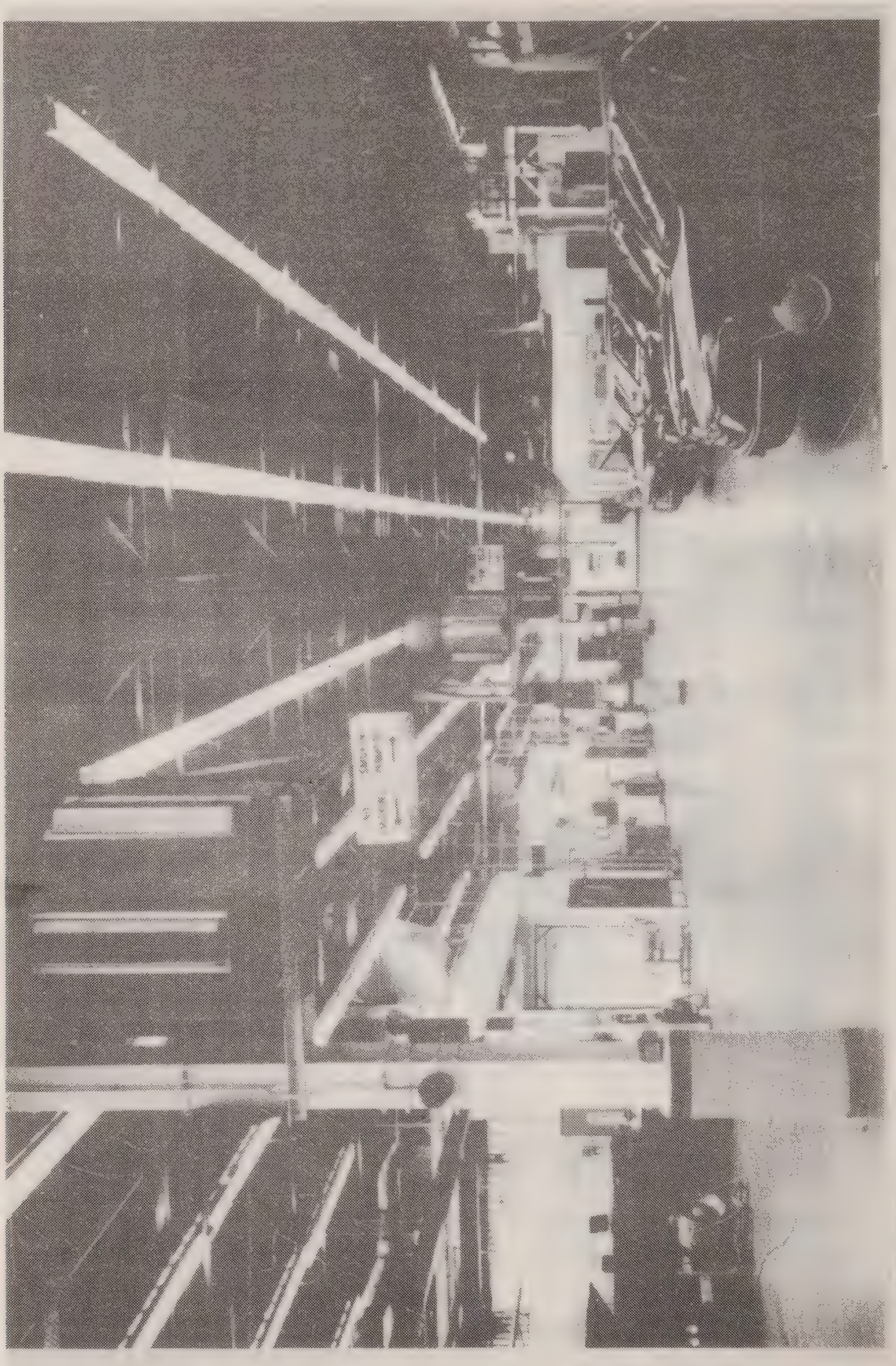


Fig. 12a. EXHAUST EMISSION LABORATORY, FORD RESEARCH & ENGINEERING CENTRE

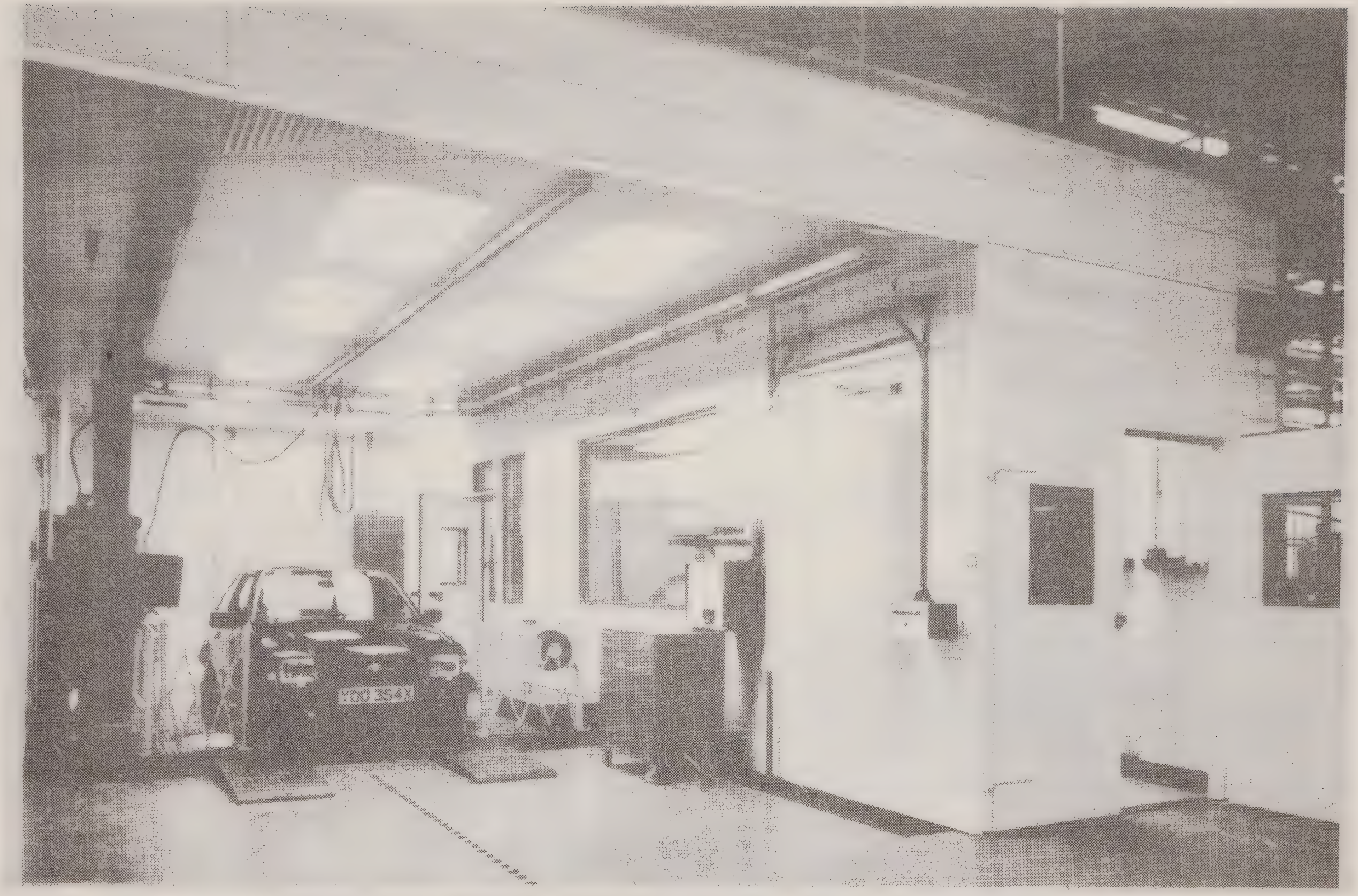


Fig. 12b. EXHAUST EMISSION TEST CELL, FORD RESEARCH & ENGINEERING CENTRE

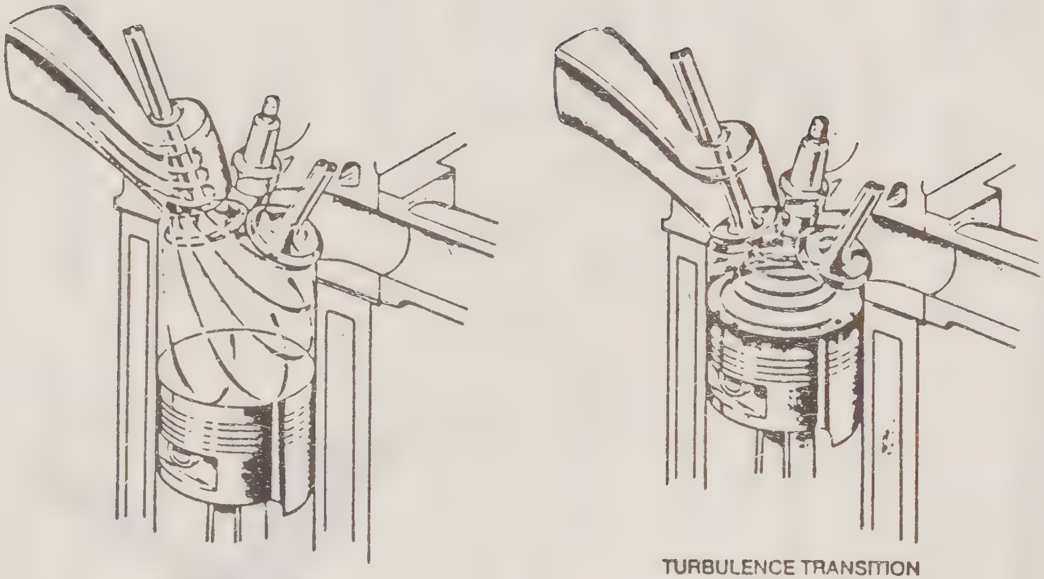
fig 13

SUMMARY OF POTENTIAL OF MAIN EMISSION CONTROL TECHNOLOGIES

SOURCE: WARREN SPRING LABORATORY

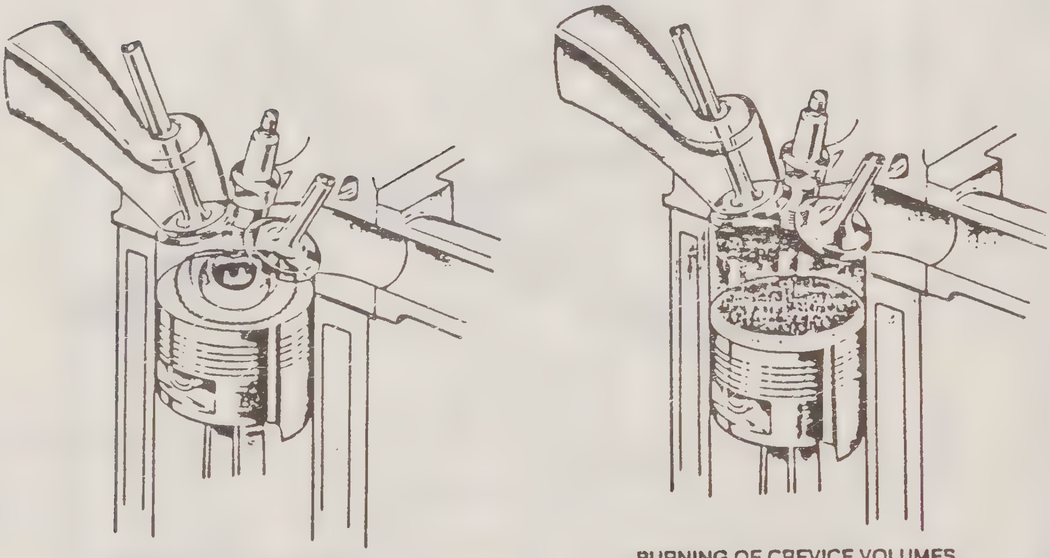
TECHNOLOGY SYSTEM	CO G/KM	HC G/KM	NOX G/KM	% CHANGE IN FUEL CONSUMPTION	COST INCREASE %
CURRENT ENGINE TO 15.03 LEVEL (BASE LINE)	10 TO 20	1.8 TO 3.6	1.2 TO 3.4	BASE LINE	BASE LINE
THREE-WAY CATALYST + UNLEADED GASOLINE	2 TO 5	0.3 TO 0.8	0.3 TO 0.9	-5 TO +17	+4 TO +22
HIGH COMPRESSION LEAN BURN (NON-OPTIMISED)	3 TO 15	0.5 TO 8.6	0.5 TO 3.2	-5 TO -20	+2 TO + 7
HIGH COMPRESSION LEAN BURN (OPTIMISED FOR CONSUMPTION/ EMISSION COMPROMISE)	~ 5	~ 2.7	~ 0.8	~ -15	+2 TO + 7
HCLB PLUS OXIDATION CATALYST	~ 3	~ 1.1	~ 0.8	~ -13	~ +10

TEST PROCEDURE AS ECE 15.03



INDUCTION SWIRL
INDUCTION STROKE

TURBULENCE TRANSITION
COMPRESSION STROKE



COMBUSTION PROGRESSION
COMPRESSION/EXPANSION STROKE

BURNING OF CREVICE VOLUMES
EXPANSION STROKE

fig 14 LEAN-BURN FLOW/COMBUSTION PROCESS fig 15 GENERAL EFFECT OF AIR: FUEL RATIO ON FUEL CONSUMPTION AND EXHAUST EMISSIONS IN THE FORD LEAN BURN ENGINE

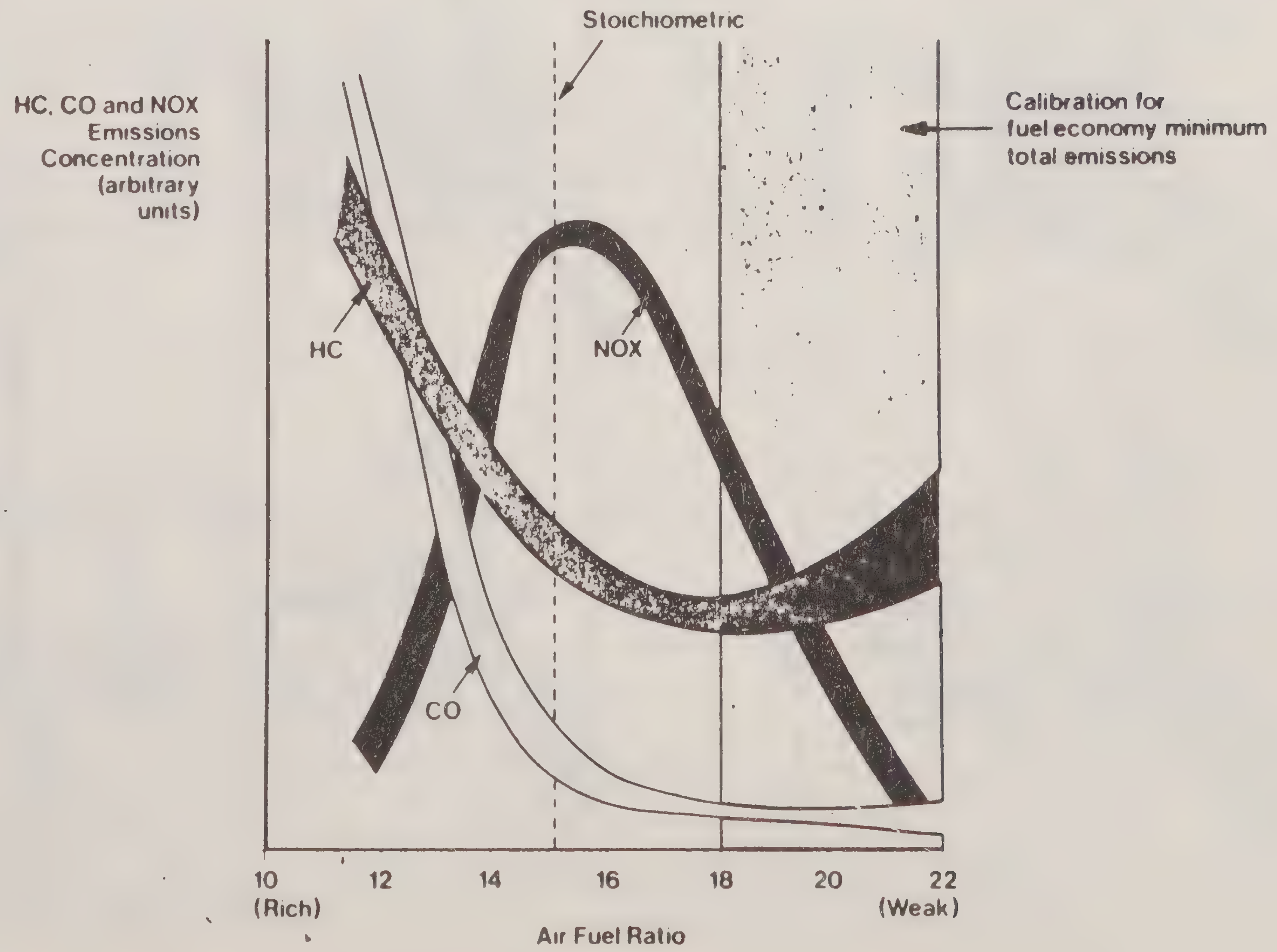


fig 16

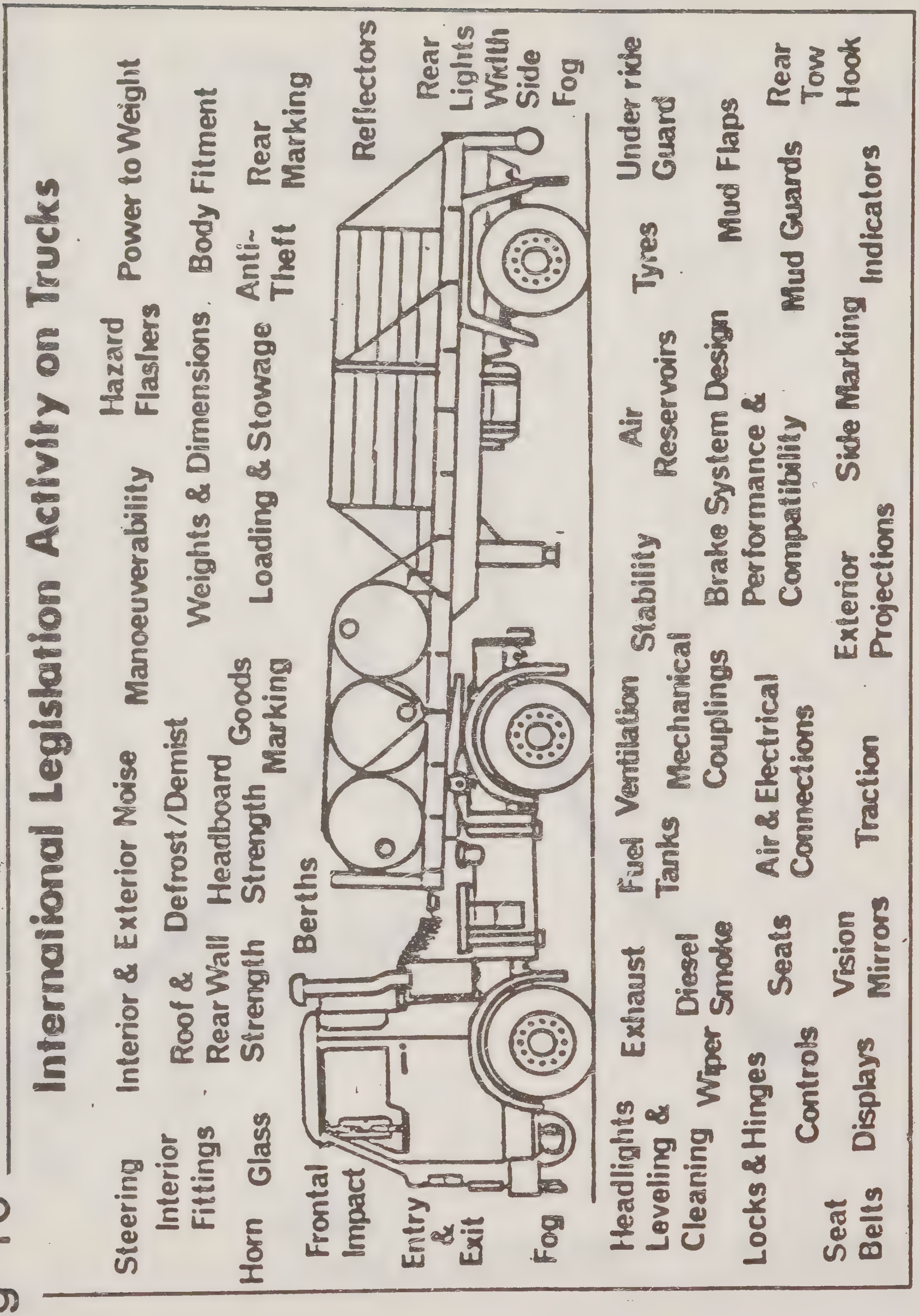

International Legislation Activity on Trucks
Steering
Interior & Exterior Noise
Manoeuverability
Hazard Flashers
Power to Weight
Interior Fittings
Roof & Rear Wall Strength
Defrost/Demist
Headboard Strength
Goods Marking
Weights & Dimensions
Body Fitment
Horn
Glass
Berths
Loading & Stowage
Anti-Theft
Rear Marking
Frontal Impact
Reflectors
Entry & Exit
Rear Lights Width Side Fog
Fog
Headlights Leveling & Cleaning
Exhaust
Diesel Smoke
Wiper
Fuel Tanks
Ventilation
Mechanical Couplings
Stability
Air Reservoirs
Tyres
Under ride Guard
Locks & Hinges
Seats
Air & Electrical Connections
Brake System Design
Mud Flaps
Controls
Performance & Compatibility
Mud Guards
Rear Tow Hook
Seat Belts
Displays
Vision Mirrors
Traction
Exterior Projections
Side Marking
Indicators

fig 17 INTERRELATIONSHIP BETWEEN - TIME:TECHNICAL RESOURCES:FUNDS FOR A GIVEN ENGINEERING TASK

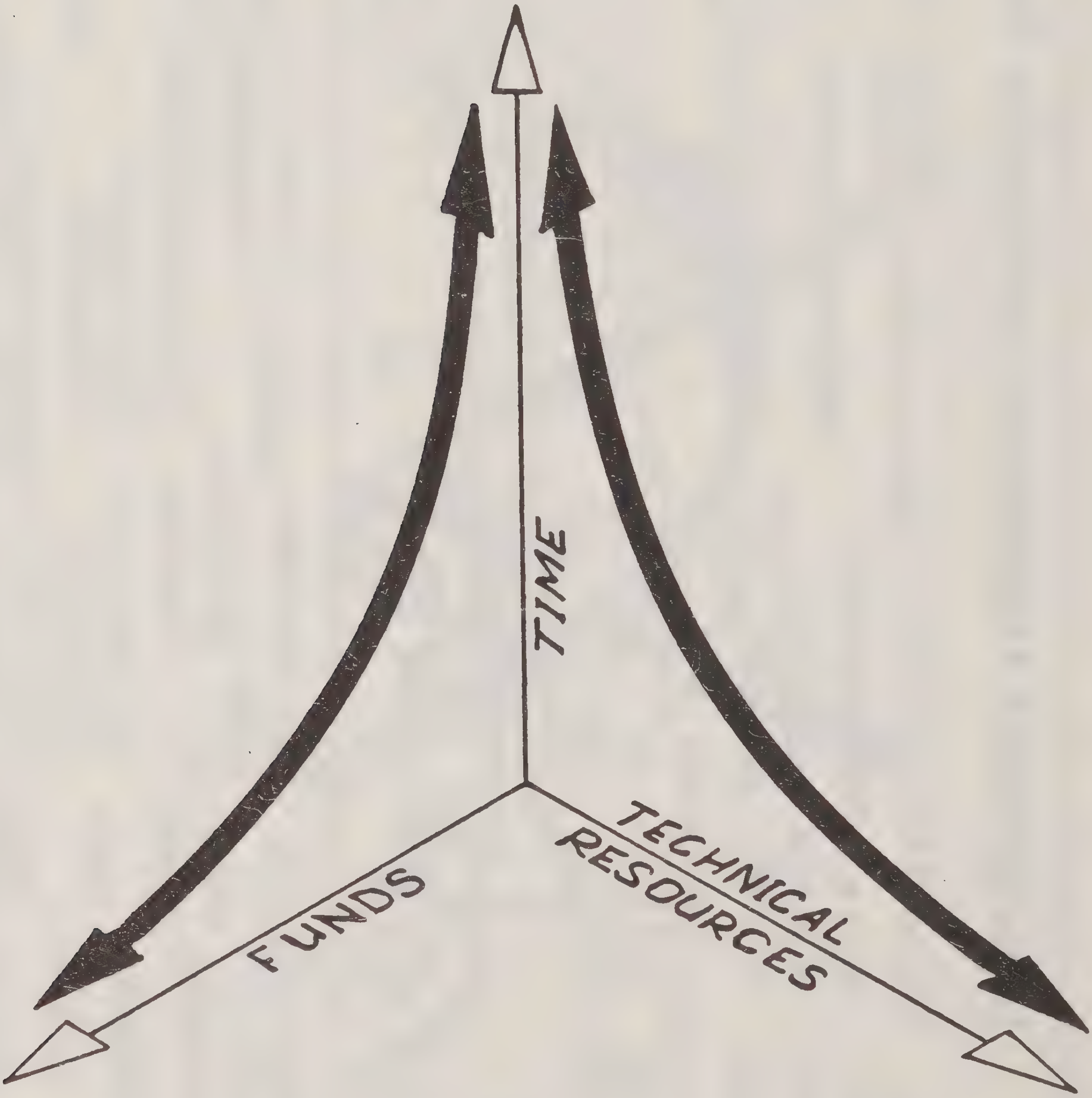
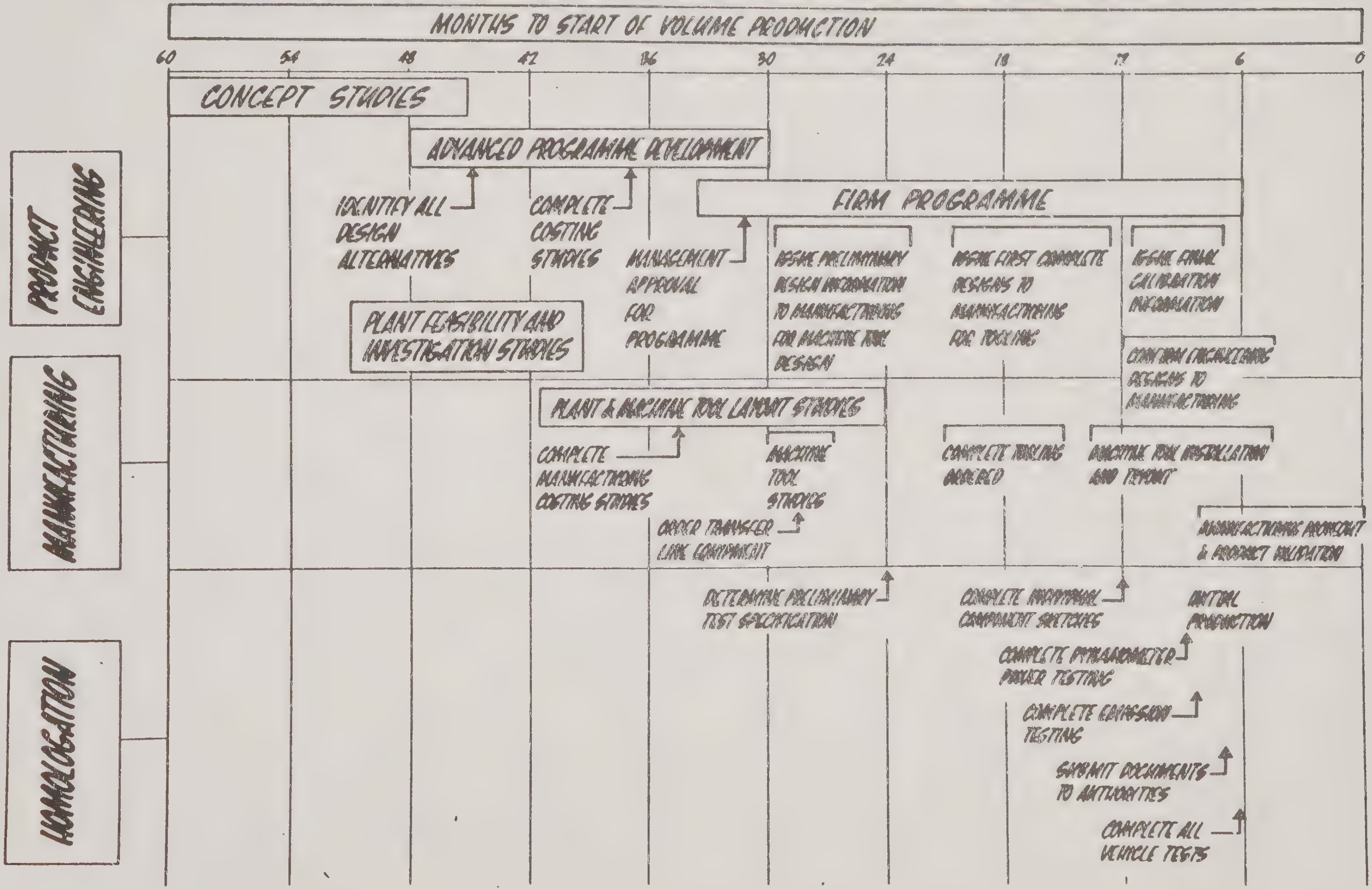


fig 18 TYPICAL TIME SCALE TO IMPLEMENT NEW PRODUCT DESIGNS AS APPLIED TO CONVENTIONAL VEHICLES AND ENGINES


MONTHS TO START OF VOLUME PRODUCTION
60
54
48
42
36
30
24
18
12
6
0
PRODUCT ENGINEERING
MANUFACTURING
HOMOLOGATION
CONCEPT STUDIES
ADVANCED PROGRAMME DEVELOPMENT
IDENTIFY ALL DESIGN ALTERNATIVES
COMPLETE COSTING STUDIES
FIRM PROGRAMME
MANAGEMENT APPROVAL FOR PROGRAMME
ISSUE PRELIMINARY DESIGN INFORMATION TO MANUFACTURING FOR MACHINE TOOL DESIGN
ISSUE FIRST COMPLETE DESIGNS TO MANUFACTURING FOR TOOLING
ISSUE FINAL CALIBRATION INFORMATION
CONFIRM ENGINEERING DESIGNS TO MANUFACTURING
PLANT FEASIBILITY AND INVESTIGATION STUDIES
PLANT & MACHINE TOOL LAYOUT STUDIES
COMPLETE MANUFACTURING COSTING STUDIES
MACHINE TOOL STUDIES
ORDER TRANSFER LINE COMPONENT
COMPLETE TOOLING ORDERED
MACHINE TOOL INSTALLATION AND TRYOUT
MANUFACTURING PROVEOUT & PRODUCT VALIDATION
DETERMINE PRELIMINARY TEST SPECIFICATION
COMPLETE PROTOTYPE COMPONENT SKETCHES
INITIAL PRODUCTION
COMPLETE DYNAMOMETER POWER TESTING
COMPLETE EMISSION TESTING
SUBMIT DOCUMENTS TO AUTHORITIES
COMPLETE ALL VEHICLE TESTS

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51st ANNUAL CONFERENCE
1 – 4 OCTOBER 1984
BRIGHTON

ASBESTOS – THE RISKS OF EXPOSURE

By

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ASBESTOS

Asbestos is the generic term for a group of naturally occurring mineral silicate fibres. For practical purposes the types of fibre which are important in the United Kingdom are chrysotile (white asbestos) - a serpentine mineral; and crocidolite (blue asbestos) and amosite (brown asbestos) - both amphiboles.

These different types of asbestos have different physical dimensional properties when seen under the electron microscope. The chrysotile fibres are longer and more wavy than the amphiboles. Crocidolite and amosite fibres tend to be straight, with those of crocidolite having a narrower diameter.

IMPORTS OF ASBESTOS

All asbestos commercially used in this country has been imported. Imports started in the early years of this century. Imports of crocidolite for commercial use ceased around 1970, and imports of amosite have now reached very low levels. Imports of chrysotile, however, are still some 50% higher than they were at the end of the 2nd World War.

The main uses of the 76,000 tonnes of chrysotile imported in 1981 were in the manufacture of asbestos cement, friction materials and floor tiles, together with a number of other minor uses.

ASBESTOS RELATED DISEASES

The main causes of death associated with exposure to asbestos are lung cancer, asbestosis, mesothelioma of the pleura and peritoneum and possibly cancer of the gastro-intestinal tract. A number of other cancers have been associated with asbestos, such as cancer of the larynx and ovary, but the evidence for these is less strong.

In an analysis of eleven major industrial cohort studies carried out up to the end of 1980, more than 20% of the excess deaths among these workers were due to these causes (see Table 1). This figure, of course, relates to exposures to very high levels in the past (some thirty years or more ago), and not to dust levels as encountered in present day operations. However, this fraction of men have, as a result of their working conditions, experienced both a shortening of their life span and a transfer of their cause of death to one of the above causes from that from which they would have died otherwise.

ANIMAL EXPERIMENTS

In inhalation experiments with various forms of asbestos it has been found that exposed rats develop lung tumours and mesothelioma of the pleura. Their risk of lung cancer has been shown to be proportional to the duration of time for which they inhale the asbestos fibre.

The carinogenic action is thought to be related to the physical properties, and not the chemical composition, of the asbestos fibres. It is still debated which size of fibres - in relation to length and diameter - are more carcinogenic.

DOSE-RESPONSE RELATIONSHIPS

In terms of setting controls regulations for human exposure to asbestos, knowledge of the dose-response relationship is of paramount importance, In what way does the risk increase with accumulating exposure and is there a threshold? As far as lung cancer is concerned, the majority of studies are suggestive of a linear increasing risk without a threshold. However, the rate of increase in risk may be different for different industries and different fibre types, depending on how they are used.

EXPOSURE OUTSIDE THE WORKPLACE

Levels of exposure to asbestos inside buildings and in the general atmosphere have been found to be more than 3 orders of magnitude lower than the present control limits for industrial exposure (see Table 2). As a consequence there is little evidence to suggest that exposure to asbestos constitutes an important risk to the general population.

ASBESTOS AND SMOKING

There has been found to be a synergistic relationship between cigarette smoking and asbestos exposure in the causation of lung cancer. This is now generally believed to be somewhere between an additive and multiplicative interaction. As a consequence it would seem pertinent to advise present and past asbestos workers to avoid cigarette smoking if at all possible.

MESOTHELIOMA OF THE PLEURA IN ENGLAND AND WALES

The number of deaths from mesothelioma of the pleura has been increasing since the middle 1970s in men, but not in women. It has been predicted that this increase will continue until the 1990s, as a result of past high exposures in particular to amphibole asbestos.

A geographical study of mesothelioma of the pleura indicates that it is predominately located in areas of high asbestos usage in the relevant past. There is, therefore, no suggestion of another major cause of this disease in this country.

RECOMMENDATIONS

Formal prohibition of the manufacture and importation of new products made of amosite and crocidolite should be considered.

In view of the fact that all forms of asbestos can be carcinogenic, further improvements in control should be made as advances in engineering make them reasonably practicable and the use of all types of asbestos should be curtailed as safer and effective substitutes become available.

Public policy should take account of the fact that all types of asbestos are extremely durable and that products containing them may require further processing, including servicing and demolition, in circumstances where dust control may be difficult and far removed in place and time from the original production process.

Steps should be taken to ensure that measurements of exposure to asbestos in the workplace are made and recorded in such a way that it is possible to determine what benefits (if any) have occurred as a result of improvements in control of dust.

TABLE 1

DEATHS IN ELEVEN STUDIES OF ASBESTOS WORKERS

Cause of Death	Observed Deaths (O)	Expected Deaths (E)	O - E	$\frac{O}{E}$
Lung cancer	952	373	579	2.55
Asbestosis	354	0	354	
Mesothelioma	186	0	186	
G.I. cancer	573	460	113	1.25
Other causes	5897	5640	257	1.05
All causes	7962	6473	1489	1.23

TABLE 2

REPORTED LEVELS OF ASBESTOS CONCENTRATION OUTSIDE WORKPLACE

Location	Nanograms per m^3	Fibres per ml	Proportion of "standard" (0.5 fibres/ml)
Inside buildings (median level)	-	0.005	0.001
Outside buildings (highest levels)			
Factory grounds	10	-	0.0004
Factory Town Centre	10	-	0.0004
Industrial site	10	-	0.0004

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ASBESTOS – SAFEGUARDING THE NATION

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THE HISTORY

It is not easy to put this subject in perspective. The tragic story of asbestos is one of a continual realisation that the substance is more dangerous than had been previously assumed. I have no doubt that the Asbestos Industry Regulations 1931 were genuinely seen by those who brought them in as providing the means whereby the asbestos problem would be resolved. By the 1960s the state of knowledge had developed very considerably and people were again beginning to be concerned. But there were still senior people on the medical scene who were genuinely sceptical about the risks of asbestos at low fibre levels. Even in 1967 certain top medical advisers were asserting that there was no proof that asbestos was dangerous at 6 f/ml (fibres per millilitre). It is a great credit to Bryan Harvey, the then Chief Inspector of Factories, that he overrode medical prevarication (which does not make that prevarication culpable) in pushing everyone to accept a 2 fibre standard (0.2 fibres for crocidolite). This new stringent standard was to be enforced under the Asbestos Regulations 1969. [1] These were excellent comprehensive Regulations and I am certain that those who framed them were entirely convinced that they had at last got on top of the asbestos problem. Subsequently, niggling doubts began to arise. There developed a closer understanding of the problems of lung cancer and of mesothelioma. Yet further heart searching was evoked by the Grant Report 1983[2] which pointed out that the sharp cutting edge of the Asbestos Regulations 1969 had, for a variety of reasons, become somewhat blunted in the ensuing years. These and other factors including media pressure and reviews carried out by the Advisory Committee on Asbestos[3] have led to a further tightening of standards in 1984. First a reduction to a control limit of 1 f/ml and now to a control limit of 0.5 f/ml for chrysotile asbestos and 0.2 for amosite and crocidolite.

THE CRITICS

It is all too easy to look back over what has happened in the last hundred years and to be scathingly critical of the way in which the health of the nation has been protected. Behind such criticism there often lies a subconscious assumption that the knowledge and expertise of the 1970s and 1980s existed in the 1950s and before. I can ssure you it did not. I was a Factory Inspector for some 36 years from 1947-1983. In the early 1950s I was inspecting asbestos factories not unlike the notorious Hebden Bridge factory. I am conscious of the fact that I was only able to apply the Asbestos Industry Regulations 1931 within the severe limitations of the then available knowledge of asbestos and in the absence of much practical expertise which we now take for granted. In those years I walked through clouds of asbestos dust in such factories and, being conscientious, I closely studied the 1931 Regulations to see in what way I could secure improvements. Bear in mind there were no means available to me then for measuring fibre levels. I could only make a rough guess at the efficiency of the exhaust and if this was clearly falling apart then I could have sought or enforced improvements under the Regulations but even supposing I had been able to measure fibres per millilitre my understanding is that if I had translated the prevailing gravimetric standards into fibres per millilitre the then acceptable limit would have been something like 175 f/ml which nowadays we would rightly regard as ridiculous. I recall discovering that one thing I could get improved under the 1931 Regulations was the type of bag in which the asbestos arrived at the factory.
I managed to get impervious sacks as required by the 1931 Regulations instead of hessian sacks but even this turned out to be a hollow victory because the impervious sacks tended to release all the fibres upwards into the worker's breathing zone rather than dispersing them in all directions as did the

hessian ones. That is typical of the practical problems with which inspectors were faced in earlier days. Not only inspectors, of course, but also manufacturers and workers.

THE PRESENT

But where are we now? Figure 1 shows UK asbestos usage. Clearly this has declined dramatically since 1973. Eventually we may reach the stage when asbestos is no longer imported and all that which has been imported is returned below ground. But that day is a long way off.

Figure 2 is disturbing because it shows that asbestos-related deaths from mesothelioma and from asbestosis as recorded on death certificates are still increasing. 'Ah', say some people 'do not worry, it is all due to improved diagnosis'. But I do still worry because if that is true, and I have no means of knowing, then it means that the toll in previous years was very much worse than is indicated on the graph. Conversely, if diagnosis has not improved and we assume a 30 year time lag in the onset of the disease then it is very difficult to explain why deaths should be rising between say 1975 and 1982 if we believe that overall exposure was being reduced in the years 1945-52. It is an understatement to say that the statistics are complex. You will note also that the graph shows no indication of deaths from asbestos related lung cancer for the simple reason that these figures are not available. All in all it is safe to say that probably at least 1,200 people and possibly many more are still dying each year from asbestos related diseases in the UK.

THE FUTURE

But what of the future? There are 3 main areas of concern.

(1) Manufacturing industry.

(2) The stripping or removal of asbestos from existing plant and buildings.

(3) The general environment.

In general if we can take care of (1) and (2) then the environment ought to take care of itself.

MANUFACTURING INDUSTRY

First, then, we have to ensure a continued improvement in standards in manufacturing industry. The Grant Report highlighted numerous shortcomings, particularly in hygiene practices such as cleanliness, the wearing of respirators and protective clothing. People may ask how it is that managers and workers can go along with unsatisfactory hygiene practices when a substance as notoriously dangerous as asbestos is involved. There are several reasons why this happens.

(a) Managers and workers can normally look back to a time 10 years earlier when conditions were worse.

(b) A person who still feels healthy after 15 years in the industry has a curious reluctance to accept that disease may finally catch up with him.

(c) There is no immediate discomfort from breathing fairly high concentrations of asbestos fibres. If asbestos had the same immediately unpleasant effect as, say, ammonia, it would never have been a problem.

On a positive note, both the Factory Inspectorate and the Asbestos Manufacturing Industry are to be congratulated on the thorough way in which necessary improvements in hygiene are now being pursued. Provided the present effort does not fade then manufacturing industry should no longer be our main concern.

ASBESTOS REMOVAL

One major problem now is to ensure that people engaged in removing asbestos from existing plant and buildings are not unnecessarily exposed to asbestos fibres.

The risk from asbestos stripping work is greater than the residual risk in manufacturing industry for two reasons. The first is that the fibre levels created during stripping work greatly exceed the fibre levels normally associated with current manufacturing. The second reason is that the fibres released during stripping work are likely to be of the more dangerous varieties, such as amosite and crocidolite, neither of which is involved in current manufacturing processes (see Figure 3). Moreover, because of widespread public concern, not always well founded, the indiscriminate stripping of asbestos from existing buildings and plant could become a growth industry.

I know that someone will say that stripping work is now so well controlled by reputable stripping contractors and by the Asbestos (Licensing) Regulations 1983[4] that there should be no risk when these operations are undertaken. Frankly I do not believe that for a moment. In the first place, not all stripping contractors are reputable and licensing will not of itself make any difference to that. In fact the whole licensing system is not significantly better than a dog licence. What it means is that if the contractor has been law abiding enough to apply for a licence then you have a possibility of revoking the licence if he does not behave or, alternatively, of putting special conditions on the licence. But either way there are not enough factory inspectors or other enforcement agencies to ensure anything like effective control over what happens in practice. We all know that even a reputable contractor finds it very difficult at times to control what actually happens on the site when his back is turned. The difficulty as always is human nature. It is all very well to lay down strict conditions such as the wearing of respirators and protective clothing and complex hygiene procedures for decontamination, but these requirements can be very onerous in practice and there are many pressures on those actually carrying out the work to take short cuts.

Take respirators for example. They are not easy to wear. You first have to consider the fact that anything up to 50% of the population are not basically suitable for the wearing of fit type respirators. A worker only has to have a few days growth of beard, or to wear glasses or to have some facial abnormality and any fit type respirator, even a powered one, is not appropriate for him. But there are many unsuitable people pretending to wear fit type respirators. That is only the beginning of the problem. When you get into the working situation the work space may be extremely confined. Sometimes there is literally not enough room for the respirator to be worn and what do you think happens when that is the case? Also common is the problem of heat stress and general hot, uncomfortable working conditions. A respirator may not feel too bad for the first 5 or 10 minutes but do you really believe that workers in hot, arduous situations are going to keep their respirators tightly fitted for extended periods? Anything I have actually seen in the way of conditions on asbestos stripping sites does not lead me to the conclusion that it is easy to get workers properly protected for long periods of time. Indeed, at the last site I visited I found there were 2 respirators for 3 men. The visors were very badly scratched, the fans were on the blink because of a faulty connection to the batteries and as for hygiene, the respirators were thrown on the floor along with the waste asbestos. The men doing this work are not infrequently recruited direct from the dole queue with no training whatsoever.

SHOULD ASBESTOS BE REMOVED?

One of the big mistakes people have made in the last year or so is to assume that once you have identified the presence of asbestos in a building or plant then you must take immediate measures to get it removed. I think that attitude has to be very seriously questioned. In general if the asbestos material in an existing building or on existing plant is in sound condition and if you cannot foresee regular disturbance of that material then the conclusion would be that it is best left alone or, at the most, sealed in position. But remember that even the work of sealing may cause some exposure to asbestos fibre.

If you compare the present fibre levels in asbestos manufacturing industry with the fibre levels arising from the mere static presence of asbestos materials in buildings then you would rarely conclude that you ought to do anything about the asbestos in the existing building. If we take the current control limit for asbestos of 0.5 f/ml for manufacturing industry then the risk to a person employed in a building lined with asbestos in good condition is negligible by comparison. The person sitting in the building lined with asbestos would have to sit there for something like 1 million years in order to achieve the equivalent dose of a lifetime asbestos worker (see Figure 4). Most people die from some other cause before the 1 million years are up!

I know that some will argue that one single fibre of asbestos is enough to kill you. Even if that were true, what they do not tell you is that the chance of one fibre killing you is monumentally insignificant as compared with everyday risks. If you look again at asbestos manufacturing industry, the current control limit of 0.5 f/ml means the same as 500,000 fibres per cubic metre. A person working a 40 hour week at the current control limit can expect to inhale well over 10 million fibres per week, many of which will remain permanently in his respiratory system. And do not forget that, in the past, manufacturing workers have been exposed to levels exceeding 100 million fibres per cubic metre (see Figure 3). There is simply no comparison between fibre exposure in industry and fibre exposure from the mere presence of asbestos materials in buildings. This remains true even if we allow for longer exposure times in the non-industrial environment.

Sometimes the appeal to 'get rid of the last vestige of asbestos' is a very emotional one based on the fact that people are still dying from the high asbestos exposure levels of some 30 years ago. That is indeed a tragedy but given that manufacturing industry is now submitting to fairly tough controls the easiest way to repeat that tragedy in another 30 years time would be to indulge in unnecessary or careless stripping work now. Asbestos has been a great scourge but we must retain a sense of perspective. Airborne levels during lagging work in the past often exceeded 1000 f/ml (1000 million fibres per cubic metre) and few precautions were taken. Moreover, much of the asbestos in existing buildings is normally performing a useful function of some sort and if in good condition or sealed in place it will not present a measurable risk unless it is disturbed.

ASSESSMENT

I am not saying that you should never strip out asbestos either from buildings or from plant. What I am saying is that you must make a very careful assessment first. If asbestos is disintegrating then that fact will generally be obvious from a visual examination. It is important to say that it may not be at all obvious from taking atmospheric samples. As far as buildings and plant are concerned I would attach far more importance to a careful visual assessment than I ever would to atmospheric samples. Atmospheric sampling by filtering a measured volume of air and examination by phase contrast optical microscopy is designed for and is suitable for the asbestos manufacturing industry and for asbestos removal work where the levels can be expected to range from 0.1 f/ml upwards. (See Figure 3). More often than not atmospheric samples in the general environment are misleading and they will either convince you that there is no risk when there is a risk or they will convince you that there is a risk when in all honesty there is none at all. For one thing you may well collect asbestos-like fibres in a school classroom but they will be chalk (gypsum) fibres and not asbestos fibres. I repeat that once you get away from manufacturing industry into the general environment an informed visual assessment of the condition of the asbestos material is much more valuable than atmospheric sampling. You have to make an assessment not only of the condition of the asbestos but also of the regularity and severity of any probable disturbance. For example if you have an asbestos lined duct and there is no way in which you can avoid men having to go into that duct on a regular basis for inspection, for maintenance or for modifications, then there could well be an argument for the effective removal of the asbestos lining of the duct. What I am stressing is that an informed assessment is required before you rush into indiscriminate and unnecessary action. Albert, of Stanley Holloway fame, would have lived a little longer if he had resisted the temptation to poke the lion.

THE WIDER ENVIRONMENT

The risk of contracting an asbestos related disease simply from the presence of an asbestos seal on a gas oven door is negligible and yet we are regaled from time to time by television pictures of men in space suits bravely venturing to examine a supposedly defective domestic oven. Statistically people could be blown up by domestic gas explosions long before the asbestos fibres from the oven have any chance to get at them. Of course you must treat asbestos with respect but no more respect than you would accord to other useful products such as electricity and gas, and remember please that asbestos in the home is a very useful product in terms of insulation and fireproofing. What some people ought to be worrying about in their homes is that they have not got asbestos walls. Instead they have often filled their houses with plastic and foam furnishings which bring a risk of death immensely greater than anything they could achieve by lining their walls with sound asbestos board. Hence we hear almost daily of tragic family fire deaths due to rapid spread of fire, heat and toxic fumes. Let us please, therefore, try to retain a sense of perspective.

And talking of domestic services, most people are not aware of the fact that they are likely to be imbibing millions of asbestos fibres along with the drinking water supply. A recent report[5] suggests that most drinking waters in the UK contain asbestos fibres in a range from not detectable up to 1 million fibres per litre. In some parts of the world the amounts are much higher but no adverse heath effects from this ingestion have yet been established.

We need a sense of proportion also about asbestos and cigarette smoking. In the Asbestos Working Group Report[2] we drew attention to the enhanced risk of lung cancer to asbestos workers who also smoked. It has recently been suggested[6] that if the risk of lung cancer for a non-smoking non-asbestos worker is 1 then the following relationships apply:-

No smoke no asbestos	1
Asbestos worker	5
Smoker	11
Asbestos worker who also smokes	53

Logically therefore you should worry more about smoking than about asbestos.

SUBSTITUTES

This brings us perhaps to the final twist in the whole asbestos saga and that is that if we do away with asbestos we are not absolutely sure that the substitute material will prove to be significantly safer in the long run. There is a school of thought that says that any durable mineral fibres, including some man made mineral fibres, having the same dimensions as asbestos fibres, could be capable of producing the same undesirable effects as asbestos. For this reason persons using glass fibres as a substitute should specifically ensure that the fibres used are not in the respirable size range associated with asbestos. And do not be surprised to find 'enlightened' ex-asbestos manufacturers with a genuine commercial interest in persuading you to pluck out all existing asbestos material in order that you may replace it with their new-found and more expensive substitutes.

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2. Grant Report. Report of the Asbestos
   Working Group 1982/3 (HSE).

3. Final Report of the Advisory Committee
   on Asbestos.
   Volume 1, 1979 (HMSO).

4. The Asbestos (Licensing) Regulations 1983 (HMSO).

5. Asbestos in Drinking Water (1984)
   Technical Report TR 202 (Water Research Centre).

6. Hammond et al. 1980
   Lung cancer death rates (NIOSH and NOSHA).

TABLE 1

DEATH CERTIFICATES MENTIONING SPECIFIC ASBESTOSIS RELATED DEATHS 1968-1982

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Mesothelioma	155	159	194	179	210	223	240	265	309	330	391	431	458	463	494
Asbestosis with or without mesothelioma	81	78	87	94	108	107	138	147	190	184	195	178	186	273	303
Asbestosis without mesothelioma	49	51	47	65	68	77	73	97	116	131	110	104	106	139	136

UK ASBESTOS USAGE ('000 tonnes)

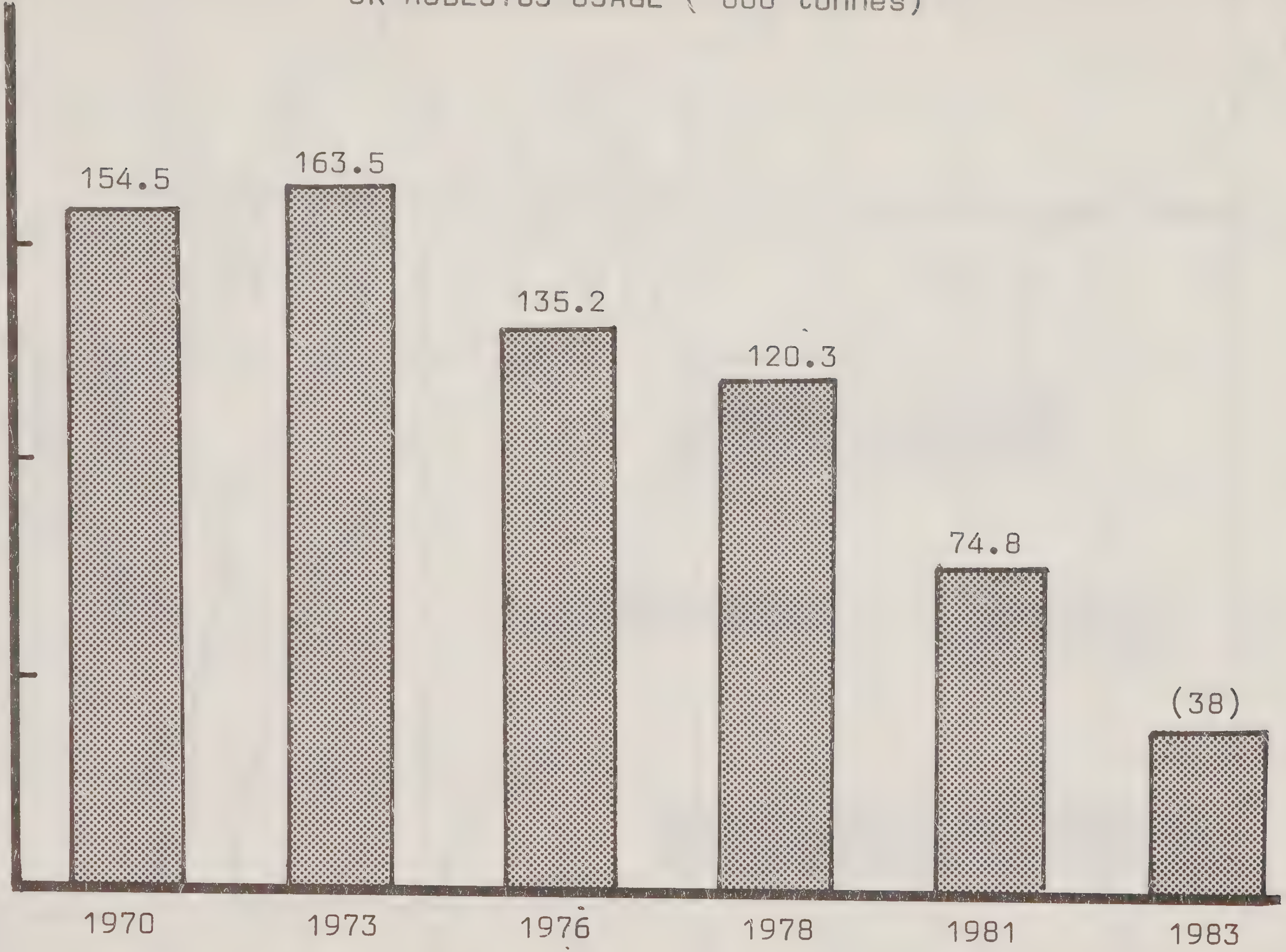

FIGURE 1

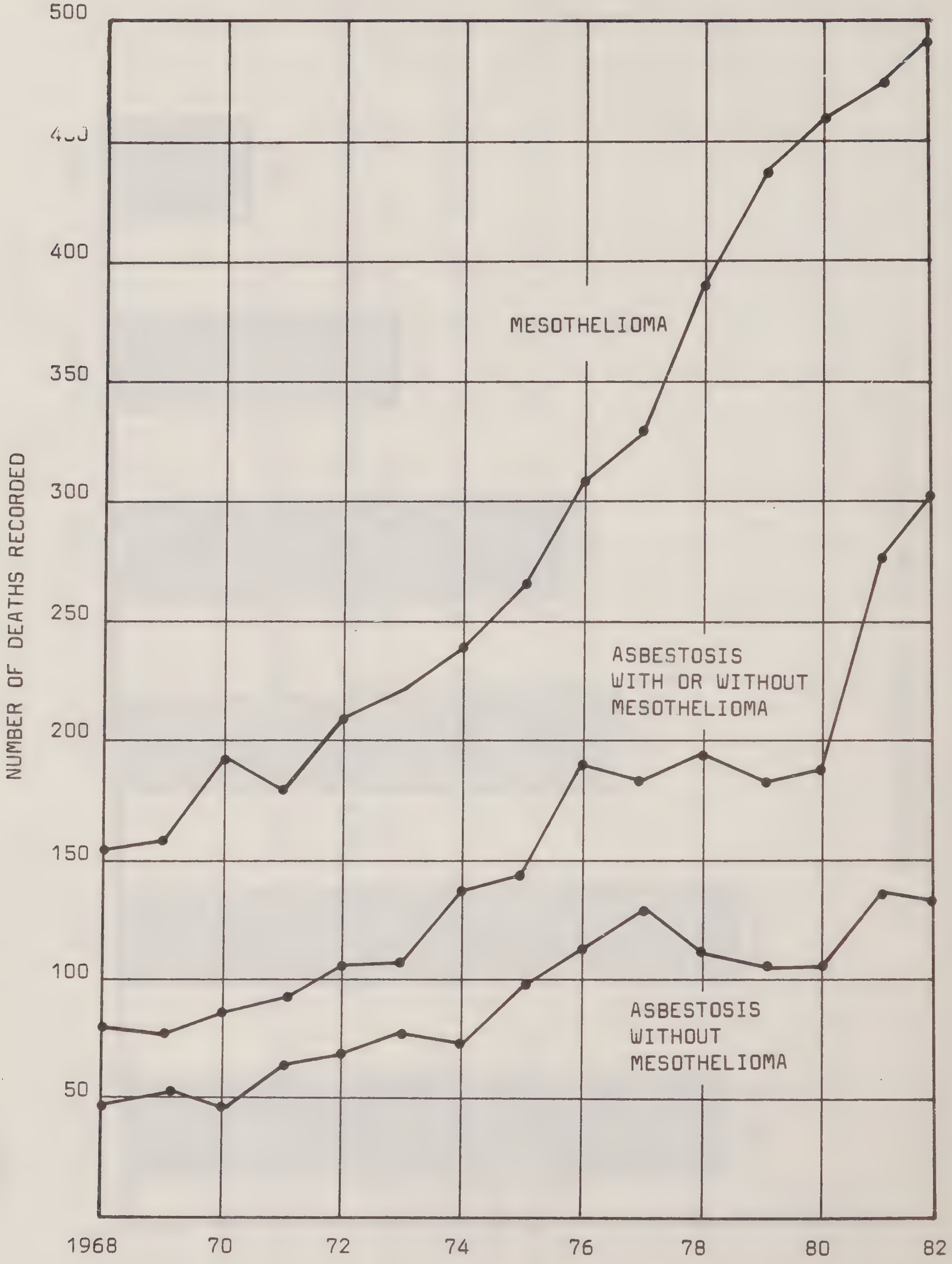

FIGURE 2 DEATH CERTIFICATES MENTIONING MESOTHELIOMA OR ASBESOSIS

COMPARATIVE EXPOSURE

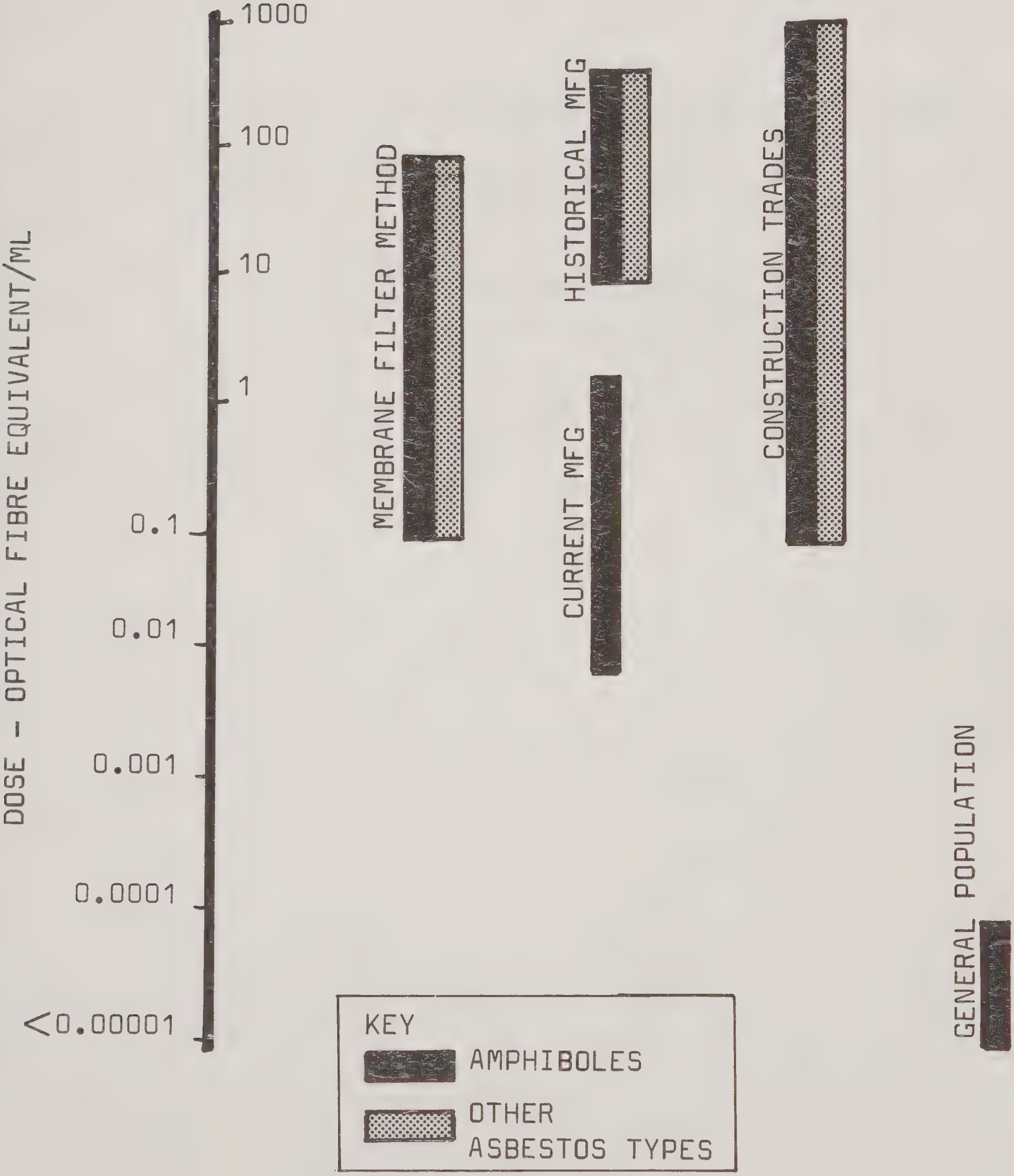

FIGURE 3

TIME FOR EQUIVALENT: DOSE

	YEARS
ASBESTOS MANUFACTURING WORKER .... (0.5 f/ml)	40
MAINTENANCE WORKER IN ASBESTOS INSULATED BUILDING .... (5 days at 5 f/ml)	200
OTHER EMPLOYEE IN ASBESTOS INSULATED BUILDING	1,000,000

FIGURE 4

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BRIGHTON

ASBESTOS – ADVISING THE CITIZEN

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INTRODUCTION

So far as the general public are concerned the whole question of asbestos within the domestic and other non-workplace environments is an emotive issue. This is not to say that public alarm is unwarranted, but in order to appreciate how the question of public advice is to be tackled it is essential to take the emotive overtones fully into account. Asbestos will not go away, it is a problem that is here to stay; even the word itself comes from a Greek word meaning "unquenchable".

If there are two things the public get het-up about it is any risk they cannot clearly see and anything that could conceivably cause "Cancer". Asbestos dust scores on both counts. Fibres of a size small enough to enter the lungs cannot readily be seen with the naked eye and the publicity given to the carcinogenic propensity of asbestos was guaranteed to produce the public response now apparent throughout much of the Country.

The public are not interested in statistics. They do not care that many other substances to which they are exposed daily (or which they freely administer to themselves - e.g. nicotine, alcohol) may well present a greater risk than asbestos in their domestic/ recreational environments. They most certainly are not interested in any calming or soothing words doled out by Local or Central Government offices.

Perhaps it is symptomatic of British democracy that the public almost automatically believe that "they" (i.e. officials of government agencies of all types) must be lying when the press, other media, and leaders of pressure groups have said that an extreme risk exists and the officials attempt to bring "facts" into the discussion.

To summarise, there are four important points to be made about public perception of this problem.

(1) The general public will tend to distrust any advice from any 'official' if it even appears to contradict the "advice" (more usually partially digested hearsay) of the media or local pressure group leaders. Here 'truth' becomes whatever the group leader tells everyone else to believe at the time.

(2) We should clearly delineate in our minds the very real difference between advice to members of the public *per se*, and advice at local meetings at which local pressure group leaders might be present.

(3) Asbestos frightens people to death more because of what it *could* do rather than because of what it has been proven to do.

(4) The public are exposed to many risks, but the only ones that really matter to them are the ones that are dramatised by the media.

All too often officials are faced with a situation in which they meet Catch 22 head on. If they don't say anything this must be an admission (of what I am not certain). If they disagree with the view of the popular media (or even try to modify the public's understanding of the 'facts') they must be lying. As the final act in this tragedy any officer who actually agrees with the media/popular view becomes the worst sinner of all, because he/she has not only betrayed his/her Authority (who, of course, will always hush up anything and everything) but has been totally spineless to boot by not themselves telling the press (or Esther Rantzen) about it before, as a member of the human race should have done.

In short, trying to advise the public is at best very like barbecueing rabid hamsters (possible, but both dangerous and somewhat pointless), whereas at its worst it comes just below canning fog in the hierarchy of lost causes.

The topic of advising the public on asbestos risks in their environment is not a simple technical problem - it is a political one and as such we cannot treat it like the technological problem it really is.

In any case, no matter what the reason for it may be, any form of public alarm is worthy of attention. Officials have a duty not only to protect the public but to be seen to be doing so. This is the very essence of democracy and I believe that openness between officials and the public is the very basis of our fundamental freedoms. The question of whether or not officials should advise the public is not open to debate. Even when any attempt to do so is bound to be less than successful, to remain silent is both irresponsible and stupid. It could even be considered to be criminally negligent. The question is, therefore, given the very considerable difficulties, how can officials best serve both their Authorities and the public at large, to both of whom they owe a duty?

HOW BIG IS THE PROBLEM

I have a friend in Industry who classifies all situations into one of two headings - little 'uns and big 'uns. Asbestos can, unequivocally, be classed as a big 'un, for it is a material that has been used for countless purposes, in large quantities, for many years. It is one of the current chief bugbears of the public. Finally, it is inevitable that the majority of the population will be within spitting distance of asbestos-containg material during their domestic, social and/or working lives. Please note that asbestos-containing materials have been used within countless types of structure. You will find them in many homes, hotels, workplaces (factories, offices, shops, etc.) and recreational/public buildings throughout the country. The number of people actually working with these materials (as part of their employment) is a very small proportion of the total number of people who have been exposed to them.

Asbestos was woven into cloth 2,000 years ago, it was mined in quantity by the Romans, in the Italian Alps and Ural mountains around 450 B.C. It is reputed that the wicks of the Vestal Virgins' lamps were made of asbestos-containing material. It has been used commercially since the 1890's, and in 1979 asbestos mining reached its peak with over six million tonnes being produced that year, worldwide.

Asbestos possesses properties unequalled by any other known mineral: even though substitutes exist, nothing can exactly match the unique properties of the asbestos minerals. Its relative abundance and usefulness has meant that it has been used in very large quantities for a great number of years.

Typically, chrysotile (white) was the most common variety used in domestic and similar buildings.

Amosite (brown) was used in thermal insulation up to the late 1960's. Amosite was also used in sprayed applications up to 1974 and as a constituent of insulating boards (1954 to 1979).

Crocidolite (blue) was used as a constituent of insulation lagging and as a sprayed coating up to about 1970, but its use alone was never extensive and it will usually be found admixed with amosite and chrysotile.

Materials found in existing buildings and new work are as follows:

Asbestos cement - 10%-12% chrysotile.
Asbestos and Vinyl floor tiles - 7% chrysotile (one brand 30% up to 1980).
Asbestos roofing felts - 8% chrysotile.
Textured paint - (Manufacturers refused to provide information regarding percentages present).

Materials present in old work (up to late 1970's) as follows:

Asbestos insulating board	- 16%-25% amosite (or mixed with amosite and chrysotile). - Possibly 1%-2% crocidolite (1955-1962).
Thermal insulation lagging	- 5%-55% chrysotile/amosite/ crocidolite.
Sprayed fire protection coatings and thermal/ acoustic insulations	- 55%-85% chrysotile/amosite/ crocidolite.

Surveys of asbestos dusts in the domestic and commercial or industrial environments have been performed as follows:

(1) Asbestos Research Council (sample 60 buildings, industrial, office, domestic)

% count	fibres/ml air
4%	0.05 - 0.08
50%	0.005- 0.05
46%	0 - 0.005

(2) Birmingham (Local Authority) (sample 759 domestic)

% count	fibres/ml air
0.4%	0.08
1.1%	0.005 - 0.08
98.5%	0 - 0.005

(3) USA (sample 36 offices)

% count	fibres/ml air
12.5%	0.1 - 1.0
62.5%	0.01 - 0.1
22.5%	0.001 - 0.01
2.5%	0 - 0.001

As can be seen from these sample surveys, the fibres per millilitre of air of asbestos vary over a fairly narrow range. Obviously, much depends upon the nature and state of material within a building and the amount of disturbance such material is liable to suffer.

WITHIN THE HOME asbestos can be found in:

- Roof and wall claddings
- Flat roof decking tiles
- Flue-pipes/gutters, etc.
- Cold water cisterns
- Roof slates
- Soffit linings
- Thermoplastic and vinyl floor tiles
- Roofing felts
- Textured paints
- Internal partitions and wall boards
- Airing-cupboard linings and shelving
- Duct and pipe covers
- Central heating systems (boilers/pipes)
- Filler ropes surrounding ovens/gas fires
- Warm-air heating systems
- Catalytic (L.P.G.) portable heaters
- Ironing boards

In addition to exposure to these materials in the home, asbestos materials have been extensively used in flats, hospitals, schools, shops, offices, public buildings, factories, etc., etc. There is no doubt that asbestos is extremely common within the built environment, almost certainly as common as timber. As if to add insult to possible injury, it is also used to carry water supply (occasionally) and as filter material for beers and wines.

It can be seen that the 'Asbestos and the Citizen' problem is most certainly a big 'un, a fact which, strangely enough, should give some comfort to the public.

DANGERS TO THE CITIZEN

No-one in their right mind would disagree that asbestos is potentially hazardous. The fact that the material can be present with potential for harm has been known since 1900, and the prime epidemiological studies into asbestosis took place in the 1930's. The association of asbestos with the malignant tumour, mesothelioma, was well known in 1960. It has been found that the proportion of people with asbestos fibres in their lungs is probably high within all industrialised areas and yet both asbestosis and mesothelioma are still quite rare diseases except amongst those persons who have been directly working with the asbestos-containing materials/ minerals.

Within the UK about 240 deaths arise annually. Asbestos accounts for 5/6ths of these and lung cancer, with mention of asbestosis, for about 1/6th.

There is no known record of anyone in the UK suffering any asbestos-related disease as a result of domestic exposure to asbestos-containing materials. In all recorded cases the sufferers had worked with such material in some way or other. The problem is that we simply do not know how dangerous asbestos in the domestic and built environment may be.

Both we and the public should take heart, however, from the facts noted previously within this paper which demonstrate just how much exposure the general public undoubtedly have to asbestos-containing materials. Such materials are so very commonly found that, were non-employment exposure to present real danger, there would surely be a far greater number of people diagnosed each year as having an asbestos-related disease.

I am not suggesting either that there is no risk (there obviously is), nor that the risk is minor. I am suggesting that we simply do not know what the risks are. Epidemiological evidence for built-environment (non-employment) induced asbestos diseases points to the potential dangers being far, far less than the public and media believe.

WHAT ACTION IS JUSTIFIED?

We know that asbestos-containing materials will be very commonly found within the built environment. The vast majority of people will live, work and play within close proximity to such material. While it would be foolish, or even negligent, to ignore this fact, it is equally foolish to over-react.

The public, in general, want all asbestos in buildings removed. This view is based, I feel, upon the unreasoned and unreasonable views of a few community pressure group leaders. As I have already indicated, any official of any Authority will be bound to be disbelieved if he or she contradicts the opinions of these amateurs. Despite this, such officials have a clear duty to balance risk against sacrifice. The simple truth is that if money, and other resources, are spent on asbestos removal programmes there will be that much less resource available for dealing with other risks, many of which present far greater danger to the public at large.

What, then, can the official do? My own approach is to tell the truth as I see it, irrespective of the consequences. If, then, the citizen chooses not to accept this he or she is free to reject it. What I am not prepared to do is to follow a line I believe to be wrong merely to pamper to the pressure groups' whims.

PLAN OF ACTION

I would recommend the following course of action so far as asbestos-containing materials within the built environment are concerned:

(1) Survey domestic, office, industrial, school, institutional and similar premises for the presence of asbestos-containing material. This in itself is expensive but is necessary, if only to help allay public fears.

(2) If any friable asbestos-containing material is found,

or any material is found in a location subject to damage (including vandalism) - remove the material and cleanse the area. Once again this is expensive but, in these cases, the opportunity for considerable exposure to fibres is too great to ignore.

(3) If the material is in good condition, and not liable to be damaged, seal it with plastic-polymer sealants. Mark the material so as to warn any workmen who may come into contact with it at any future date. It is imperative that the material is not drilled, sawn, removed or tampered with unless strict precautions for personal and third-party protection are taken. It is also a good idea to record the locations of sealed asbestos-containing materials in central registers (depending upon the building owners) so that possible danger areas can be located during future repair/rebuilding or demolition.

It is important to realise that asbestos removal is itself a most hazardous task. Strict precautions are essential, including full air-screening, personal protection and hygiene facilities for workmen and final air-test certification following removal. Removed material must be carefully transported and disposed of. (I have myself seen children using asbestos sheets as chalk following criminally negligent removal operations when asbestos sheets were merely piled into a skip awaiting collection). In some circumstances, to strip out asbestos material will create more hazard than leaving it in place.

Friable material, damaged materials and those liable to damage must be removed, others should be sealed, marked, recorded and then left alone. We will have a big enough task to achieve this, let alone stripping out all asbestos from all buildings which contain it.

ADVICE TO THE PUBLIC

I believe that the public should be told, by means of explanatory leaflets, just where asbestos-containing material may be found.

The potential dangers should be spelled out clearly; they should not be exaggerated. The difference between stripping out asbestos and sealing it should be clearly explained.

Following such general information, the points I have outlined before in this paper, regarding the relative risk of asbestos diseases, should be clearly set out. The public should be advised that any suspect material should be examined (and sampled for laboratory analysis) by the Local Authority Environmental Health Officer. That officer should then advise on subsequent action (either strip out by an experienced contractor or seal with plastic-type coatings, marking, etc.).

On no account should the public be encouraged to deal with asbestos materials themselves. Any necessary work should always be specified by the Environmental Health Officer, who should supervise all necessary works.

I appreciate only too well that this approach to the problem will be expensive, but the alternatives are either more expensive still, or present too much danger to be acceptable. The idea of members of the public performing do-it-yourself asbestos removal, or even do-it-yourself sealing, is too horrific to contemplate. Such action would almost certainly change many comparatively minor problems into major ones.

A further advantage of the approach I suggest is that the public feel reassured, first, that the problem is being treated seriously; and second, that the best advice is being given following actual investigation of each particular case. Not all asbestos incidents are alike; personal advice is always more likely to be accepted than blanket advice.

If the public are going to believe officials at all, they are far more likely to believe a face they can see, and talk to on a one-to-one basis, than an impersonal letter or circular. They are far more likely to be reassured by the personal touch, and the officer is more likely to get his/her message across to an individual than to a face in a crowd, a crowd whipped up by pressure group and media alarm.

Unquenchable asbestos will not go away, it is a problem that must be faced; but in our wish to do the right thing we must be very careful not to provide a cure that is worse, in the long run, than the disease itself.

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THE ROLE OF THE HAZARDOUS WASTE INSPECTORATE

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The report of the House of Lords Select Committee on Hazardous Waste (the Gregson Committee) published in July 1981 contained 34 conclusions and recommendations. The Hazardous Waste Inspectorate was created in response to one of those recommendations, viz. that:

> "a small Hazardous Waste Inspectorate should be set up within the Health and Safety Executive to augment the control of waste disposal authorities. Its functions should be to (1) advise waste disposal authorities and the Health and Safety Executive on the execution of their duties to control sites receiving hazardous waste, and (2) to make an annual report to Parliament. It need not have executive functions. It should encourage adequate and consistent standards of control throughout the country. It should provide a welcome second opinion at any site operated and controlled by the same authority, i.e. a waste disposal authority's site."

Despite the absence of executive powers for the Inspectorate, Lord Gregson envisaged that the two-fold role outlined above would provide it with far-reaching influence, in the same fashion as Her Majesty's Inspectorate of Constabulary. This influence would be used to ensure that standards of site licensing and enforcement were adequate and consistent across the country.

In accepting this recommendation of the Gregson Committee, however, the Government decided that the new function should be located in the Department of the Environment. The creation of the Hazardous Waste Inspectorate (HWI) was announced on 8 August 1983 by Press Release and Circular, both of which contained the following terms of reference, embodying Lord Gregson's proposals:

> "to examine the management of hazardous waste at all its stages from the point of arising to that of final disposal by visiting facilities being used to handle, store, treat, process and dispose of such

> waste either separately, or in conjunction with other controlled waste; to advise waste disposal authorities on the execution of their duties under Part I of the Control of Pollution Act, 1974; to make recommendations with the object of ensuring that standards of operation, site licensing and enforcement are both adequate to protect health and the environment, and also equitable and consistent across the country; and periodically to publish a report."

Within environment departments in the UK, the Inspectorate "hat" is located within the Department of the Environment in England, within the Welsh Office, the Scottish Development Department and DOE, Northern Ireland. Whilst in line management terms, therefore, HWI staff in the four constituent parts of the UK answer to different masters, in professional terms there are very strong links with one another and with the Chief Inspector in England. A small multi-disciplinary HWI Advisory Committee has been set up, on which all the territorial interests are represented, together with HSE, MAFF, Local Authority Associations, the National Association of Waste Disposal Contractors, the Chemical Industries Association and the Confederation of British Industry, and thus far no problems have emerged in maintaining a consistent approach.

Any consideration of the role of the Inspectorate must be made against the predominant theme of the Gregson Report - that of the need for greater public confidence in hazardous waste management. Indeed, Lord Gregson, writing in the Waste Management Bulletin No. 2, suggested that if he had to scrap nearly the whole of the House of Lords report on hazardous waste management and give only one sentence it would be that "the heart of successful waste disposal is public confidence and acceptance."

The Gregson Committee highlighted the difficulties surrounding the definition of such basic facts as the total quantity of hazardous waste generated in the UK, its geographical distribution, patterns of movement, etc. One clear role for the Inspectorate is to remedy this deficiency, and achieve a better understanding of these fundamental statistics. To this end, the Inspectorate has embarked on a programme of visits to producers of hazardous waste, to waste disposal authorities (wdas) and to disposal site operators. This is designed to ensure that in the first year of operation in England, for example, the twelve wdas in whose areas 75% of the approximately 4 million tonnes of hazardous waste arising annually is either generated or disposed of, are visited, together with the 100 major contractual and in-house hazardous waste disposal facilities. It is also intended to visit all English wdas on an informal, introductory basis - aimed at establishing relationships with wda staff and at gathering basic information.

In Scotland and Wales, where the District Councils are the wdas, the priority is on visiting the most heavily industrialised wda areas - roughly speaking, the Central Valley in Scotland and South Wales. In Northern Ireland, all District Councils have been visited.

In addition, the Inspectorate has commenced the investigation of certain known problem areas, namely the production, handling and disposal of acid tars, the disposal of asbestos and the disposal of drummed wastes by landfill. The interface between certain aspects of the chemical recovery industry and waste disposal is being examined, together with an assessment of the standards of site licensing, enforcement and site operation which are currently achieved. For England and Wales, the Inspectorate has produced a register of all licensed disposal sites for controlled wastes, shortly to be published. Conceived as a valuable tool to assist with the planning of hazardous waste management, the exercise of producing the register has demonstrated a marked lack of consistency in site licensing between wdas.

The Inspectorate is, and is likely to remain, a small unit. As will be apparent from the terms of reference and from the tasks set out above, if the Inspectorate is to make a significant impact on the standards of hazardous waste management in the UK - or, indeed, if it is to hold educated opinions on the matter - it will have to adhere fairly rigidly to a pre-planned programme, aimed at achieving a systematic appraisal of the current situation.

It is important to emphasise that the Inspectorate has no enforcement powers, although the Government has not ruled out a possible future statutory function should the need become apparent. Executive powers with respect to controlled waste management in the UK are vested in the 46 English, 37 Welsh, 56 Scottish and 27 Northern Ireland waste disposal authorities, and the Inspectorate is cast in the role of a consultative, advisory body.

Perhaps the major role of the Inspectorate, however, is to provide an experienced presence at the sharp end of hazardous waste management which is independent of sectoral interests - concerned, and seen to be concerned, with the achievement of adequate, fair and consistent standards across the country. Whilst this will be achieved by the dissemination of the waste management policies of the Department of the Environment, as exemplified by the guidance contained in the series of Waste Management Papers, it will not necessarily be by slavish interpretation of such conventional wisdom. That is to say that the Inspectorate will act by encouraging waste management by the best practicable means, but will expect to be instrumental in effecting changes to the Department's appreciation of what constitutes the best practicable means.

If progress in hazardous waste management is to be achieved, it is essential that this two-way exchange is maintained. In encouraging the attainment of the best practicable environmental option, the Inspectorate liaises closely with HM Industrial Air Pollution

Inspectorate with respect to chemical waste incineration and with MAFF with respect to the disposal of hazardous waste to sea under the Dumping at Sea Act, 1974.

There is a third role for the Inspectorate, which arises naturally out of its duty to encourage adequate and consistent standards: that of considering the legislation controlling the management of hazardous waste. Consider a waste disposal operation which when assessed according to an appropriate set of criteria is judged to be well below current standards of good practice. Where such a failing is due to inadequate site licence conditions or to a failure to enforce the conditions of the site licence, then there is an obvious course of action for the Inspectorate, which would make appropriate recommendations to the site operator and the waste disposal authority. Where the failing was not apparently due to either of these causes, but was seemingly due to legal problems making enforcement impossible, thus enabling the site operator to disregard the site licence conditions concerned, then there is a very clear duty for the Inspectorate to consider the implications and, if necessary, to make recommendations for changes in the law.

Fourthly, there is the Inspectorate's reporting role. The Inspectorate has a duty to publish a report: this will take the form of a report to the Secretary of State for the Environment, and will be laid before Parliament. It is in this document that the Inspectorate's findings can be set out publicly, together with its recommendations for effecting improvements. In it will be examined the impact of current Government waste management policy as it influences the management of hazardous waste in the UK.

Inevitably, the Inspectorate has already been identified as, at least potentially, an independent arbiter in local disputes, and some lobbying has already been experienced with attempts to enlist the Inspectorate's support, for example:

(a) by District Councils against County Councils;

(b) by contractors against County Councils, alleging dual standards;

(c) by County Councils against waste producers;

(d) by members of the public against various public and private sector organisations concerned with waste management.

The Inspectorate takes the line that it will always be willing to assist in such issues, where they come within its terms of reference, and indeed, the cause of increased public confidence would hardly be well served by any other response. Herein lies a very real dilemma. Involvement in such issues can be very time consuming in terms of slender Inspectorate staff resources and thus any such assistance can only be provided at the expense of other duties. The more the Inspectorate is diverted into a responsive mode of action on site specific inquiries, the less it will be able to achieve in terms of its primary role of encouraging adequate and consistent standards of operation, site licensing and enforcement on a national basis. There is, nevertheless, an arbitration role for the Inspectorate, a role which it does not seek but which will undoubtedly be forced upon it to some degree.

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RADIOACTIVE WASTES

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1. INTRODUCTION

"In the future, a rapid extension of nuclear capacity may come to be regarded as the best method of reducing atmospheric pollution from energy production. However, we repeat that such a strategy should not be supported in the United Kingdom, unless there is an unqualified commitment to the principles set out in the Sixth Report. Of these, we would stress in particular the need to maintain the nuclear industry's safety record, the development of satisfactory waste disposal policies, and the availability of information to enable all relevant issues to be debated and resolved fully and publicly."

The above quotation is taken from the chapter on Air Quality in the Tenth Report of the Royal Commission on Environmental Pollution(1). I have used it as a basis for preparing this paper because it highlights four topics which I think will be of interest to conference participants. These are:

(i) the radiological impact of present day waste disposal methods, particularly routine releases of radioactive materials to the atmosphere;

(ii) the standards which are applied to radioactive waste disposal and the way in which these standards are implemented;

(iii) the development of methods for future disposal of radioactive wastes; and

(iv) the availability of information on radioactive waste management issues.

These four topics are dealt with in subsequent sections of this paper. As background, the types of radioactive wastes which are produced by the UK nuclear industry are first described, together with the methods used to manage and dispose of them at present, and those being considered for the future.

2. WASTE TYPES AND MANAGEMENT METHODS

The nuclear industry produces gaseous, liquid and solid radioactive wastes. Gaseous and liquid wastes which have a low radioactivity content are discharged directly into the environment. Those containing higher levels of activity are, with one exception, treated to remove most of the activity and then discharged. The exception is the high activity liquid wastes produced during the first cycle of the reprocessing of spent nuclear reactor fuel. These wastes contain over 95% of all the radioactivity arising in the nuclear fuel cycle. At present they are stored in specially constructed, cooled tanks at the British Nuclear Fuels (BNF) plc site at Sellafield in Cumbria. A plant to solidify these wastes by incorporating them in glass is to be built within the next few years. The resulting vitrified high-level waste is to be stored for several decades to allow its heat output to decay prior to eventual disposal(2).

The solid wastes arising in the nuclear fuel cycle can be divided into three categories: high-level (or heat generating) (HLW), intermediate level (ILW) and low level (LLW). In its Fifth Report to the Secretary of State for the Environment(3), the Radioactive Waste Management Advisory Committee (RWMAC) gives definitions of these categories, emphasising that the classification scheme is not intended to prescribe the disposal route which will be acceptable for particular wastes but to provide a clearer indication for the layman of the relative levels of radioactivity in wastes. These definitions are shown in Table 1, together with examples of the types of waste materials which fall into each category. To provide some perspective, in Table 2 the masses of HLW, ILW and LLW are compared with arisings of non-radioactive wastes.

At present, all the HLW produced in the UK and in other countries is stored. However, there are large national and international research programmes on methods for its eventual disposal. World-wide, most research effort on HLW disposal is being devoted to emplacement in deep geologic formations on land(5), but there is also a substantial, internationally co-ordinated research programme(6) on emplacement beneath the bed of the deep ocean. In the UK, both of these options are being studied, but more effort is now being devoted to sub-seabed disposal because research into this option is at an earlier stage than that on geologic disposal. In view of the technical advantages in storing HLW for several decades, there is no urgency to develop disposal facilities for these wastes and it seems unlikely that any country, with the possible exception of the US, will dispose of any HLW until the year 2000 at the earliest(7).

For ILW and LLW the situation is quite different. Since neither ILW or LLW generate heat there is no advantage in storing them. Continued storage involves radiation doses to workers, and financial costs, both of which can be avoided by early disposal. Also, these wastes will have to be disposed of at some time and doing so earlier, rather than later, involves no extra risks to the public and may result in a decrease in risks. For these reasons the Government has taken the view that ILW and LLW should be disposed of as soon as is practicable(2).

At present, some LLW is disposed of by burial at shallow depth on land, the main disposal site being Drigg in Cumbria. Until recently the remaining LLW and also some ILW were disposed of by sea dumping at a site in the N.E. Atlantic, some 600 km from the nearest land. Industrial action by the transport unions prevented the planned sea dumping operation in 1983, and a resolution was carried by the Trades Union Congress in September 1983 opposing any radioactive waste disposal at sea. Subsequently, a TUC delegation met the Secretary of State for the Environment, and a panel of independent scientists, under the chairmanship of Professor F. Holliday, was set up to review the scientific evidence and the environmental implications relevant to the safety of sea dumping in the N.E. Atlantic. The Government have said that no sea dumping will be carried out until this review has been completed.

Whether sea dumping continues or not, there is a need to establish new land disposal facilities for both ILW and

LLW. This need was recognised some time ago and in 1982 the Nuclear Industry Radioactive Waste Executive (NIREX) was set up, primarily to carry out this task. In 1983, NIREX announced its interest in two possible disposal sites: a clay formation at Elstow in Bedfordshire for a shallow depth, engineered facility for LLW and shorter-lived ILW, and a disused anhydrite mine at Billingham in Cleveland for the longer-lived ILW. Before decisions are taken about constructing any new land disposal facilities, there will need to be detailed investigations of the sites and Public Inquiries.

3. STANDARDS AND THEIR IMPLEMENTATION

3.1 Radiological Protection Standards

In the UK, as in almost all other countries, the radiological protection standards which are applied to waste management are based on the recommendations of the International Commission on Radiological Protection (ICRP). ICRP is an autonomous scientific organisation which has published recommendations on protection against ionising radiation for over 50 years. Governments evaluate its recommendations and put them into practice in ways which are appropriate to the countries concerned. In addition, international organisations use ICRP recommendations as a basis for developing guidance and standards (see, for example, reference 8). Following a Direction from the Health Ministers in 1977, the National Radiological Protection Board (NRPB) has the responsibility to advise on the acceptability and applicability of internationally recommended standards for use in the UK. NRPB advice is published in short formal statements(9-12), and further guidance is provided in a series of reports(13-16).

The fundamental principle on which ICRP recommendations are based is that the risks to people from radiation exposure should be kept to acceptable levels. It is important to recognise, however, that ICRP does not actually recommend acceptable levels of risk. What it does is to recommend a system of dose limitation(17) which is designed to ensure that doses (and hence risks) are acceptable. The two requirements of this system which are, in principle, directly applicable to waste management and disposal are:

(i) that all exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account (the ALARA principle or optimisation of protection);

(ii) that the dose limits recommended by ICRP for individuals shall not be exceeded.

In waste management, the practical application of the dose limits is in screening out those options which are definitely unacceptable, while the ALARA principle is applied by comparing possible, potentially acceptable options on the basis of their radiological consequences, financial cost and other factors. The dose limits recommended by ICRP for members of the public are shown in Table 3.

The ICRP system of dose limitation can be, and is, directly applied to the routine discharge of gaseous and liquid effluents from nuclear installations. However, some difficulties arise in applying it to some of the options which are in use or under consideration for disposal of solid wastes. Over the past few years, these difficulties have been under discussion in several international organisations, including the Nuclear Energy Agency (NEA) of OECD, the International Atomic Energy Agency (IAEA) and ICRP itself. The consensus which is emerging from these discussions(18) is that radiological protection objectives for disposal of solid wastes should consist of:

(i) a requirement that the risk to an individual should not, at any time, exceed a specified level, with risk being defined as the product of the probability that a dose will be received and the probability that the dose will give rise to deleterious health effects;

(ii) a requirement to apply the ALARA principle within the broader context of decisions on waste management strategies.

This consensus is reflected in guidance issued by the NRPB(16) and in a consultative document issued by the Authorising Departments on principles to be applied in assessing land disposal facilities for low and intermediate level wastes(19). The limits on individual risk recommended by NRPB are given in Table 3, alongside the corresponding ICRP dose limits. The main implication of using standards which are based on risk is that, when performing radiological assessments of disposal options, both the probabilities and the consequences of releases of radioactive materials into the environment should be taken into account. This is consistent with the approach adopted for the licensing of nuclear reactors and nuclear chemical plants.

Before describing the roles of the various organisations in implementing standards, it is perhaps worth saying a few words about the interpretation and application of the ALARA principle. As noted in the Fifth RWMAC Report(3), in recent months the application of the ALARA principle has come under close scrutiny, particularly in the context of the regulation of discharges from the British Nuclear Fuels plc reprocessing plant at Sellafield. In advising the Secretary of State for the Environment on this question, RWMAC made the point that the objectives of ALARA are identical to those of the more general principles of "as low as reasonably practicable" (ALARP) and "best practicable means" (BPM) which have been used for many years in pollution control in the UK, and will be more familiar to conference participants than ALARA. All three principles embody the idea that in deciding on the standards to be applied to practices it is necessary to compare alternative courses of action (in both operation and design) on the basis of the risks which they entail to workers and the public, their financial costs, and other, qualitative factors such as public acceptance and the current state of technical knowledge. The relative weights to be assigned to these factors are clearly matters for judgement, and there is no one automatic recipe for deciding when the objectives of ALARA, ALARP or BPM have been met. Formal techniques such as cost-benefit analysis, which has been the subject of considerable interest in radiological protection(12,20), can provide an input to decisions. However, their main value is in providing a means of structuring judgements, and ensuring consistency, openness and well-defined reasoning when decisions are made.

3.2 Implementation

Disposal of radioactive waste requires an authorisation under the Radioactive Substances Act, 1960. The Government Departments which have the responsibility for authorising disposals are the Department of the Environment, the Ministry of Agriculture, Fisheries and Food, the Scottish Office, the Welsh Office, and the Department of Environment for Northern Ireland. The responsibility for regulating the safety of workers involved in radioactive waste management rests with the Health and Safety Executive (HSE). Before any new waste disposal facility was constructed, it would need a licence from the Nuclear Installations Inspectorate of HSE, under the Nuclear Installations Act 1965, and before any disposals took place authorisation would be required.

NRPB's role in the implementation of radiological protection standards is an advisory one. The practical situation is that NRPB provides advice which the Authorising Departments and HSE then take into account when formulating more detailed regulations, and that throughout this process there is extensive consultation amongst the organisations involved.

4. RADIOLOGICAL IMPACT OF PRESENT WASTE MANAGEMENT PRACTICES

As part of its statutory duties, the NRPB keeps under review the radiation exposure of the UK population from all sources. This information is published periodically both in the form of detailed reports on particular topics (see, for example, references 21-23) and as shorter summaries (e.g. reference 24). This work shows that the average annual radiation dose to members of the public from radioactive waste disposal is only about 0.1% of the dose which they receive from all sources, natural and artificial (see Figure 1). This information is useful as perspective, but to gain an appreciation of the impact of waste disposal and to identify areas where improvements are required it is necessary to know the maximum individual doses, and the collective doses to the whole population. These two topics are dealt with below.

4.1 Gaseous Effluents

In 1981 the NRPB carried out an assessment of the radiation exposure of the UK population from airborne effluents discharged from civil nuclear installations in the UK. This assessment(21) was concerned primarily with collective doses, which were calculated using mathematical models. For completeness, estimates of maximum individual doses were included; these were based on information published by the nuclear establishments and the Authorising Departments. The locations of the installations considered in the study are shown in Figure 2. The effluent discharges used were those for the calendar year 1978, because at the time of the study this was the most recent year for which a comprehensive compilation of discharge data was available. However, results were presented in a form from which the impact of discharges in other years could be readily determined and, since annual airborne discharges have not varied greatly over subsequent years, dose estimates for 1978 discharges are a good indication of the present situation.

The results of the assessment are summarised in Table 3 and Figure 3. They show three features which are of particular interest. The first of these is that both the total collective dose commitment (i.e. the population dose integrated over all time) from all gaseous discharges and the maximum individual dose from each installation's discharges are very low. At 14 man Sv the collective dose commitment is of the order of 0.01% of the annual collective dose from natural background radiation (104,000 man Sv), while the highest individual dose is less than 6% of the ICRP dose limit (and hence about 16% of the average individual natural background dose). The second feature is that the radionuclide which makes the greatest contribution to the collective dose commitment is carbon-14. This is a relatively long-lived radionuclide (half-life 5,700 y) which becomes globally dispersed and thus gives rise to "first pass" doses immediately after discharge, and to doses over long time periods. The third feature is that the installations whose discharges contribute most to collective doses are the BNF plc Sellafield reprocessing plant and CEGB/SSEB reactors.

4.2 Liquid Effluents

In parallel to the study summarised above, an assessment was also carried out on the radiation exposure of the UK population from liquid effluents discharged from civil nuclear installations(22). The results of this study will not be described in detail here because the most important of them, i.e. those related to liquid discharges from Sellafield, have been superseded by more recent work. It is worth noting, however, that the calculations showed that the collective dose commitment from Sellafield (then Windscale) 1978 liquid discharges was 134 man Sv, while that from liquid discharges from all other civil nuclear installations in the UK was only about 1 man Sv.

Over the past few years, several developments have occurred which have led to revision of the estimates of the radiological impact of the Sellafield liquid discharges. As far as collective doses and maximum individual doses are concerned the most influential of these developments have been:

(i) a reduction in the amounts of radioactivity discharged (particularly caesium-137, which makes the greatest contribution to collective dose, and the long-lived alpha-emitting radionuclides which lead to the highest individual doses);

(ii) new habit surveys in the Sellafield area have identified a small number of people who eat relatively large quantities of molluscs and thus constitute the "critical group";

(iii) research on the metabolism of radionuclides has led to an upward revision in the dose per unit intake factor for ingestion of plutonium incorporated in biological materials.

The effect of these developments on radiological impact estimates is shown in Table 5. In addition, there has been increasing interest in exposure pathways which had not been considered in detail before because they were felt to be of minor importance. These include the inhalation of radioactive material associated with sea spray, and the inhalation and ingestion of household dust containing alpha-emitting radionuclides, particularly plutonium. At the time of writing this paper research on the household dust pathway was still in progress, so it was not possible to make a revised estimate of the doses received by this route. However, preliminary results suggest that it is unlikely to be a significant source of exposure. Individual doses via the sea spray pathway have been estimated and have been shown to be in the range 0-25 u Sv(25) (i.e. up to about 1% of natural background).

4.3 Solid Waste

4.3.1 Shallow Land Burial at Drigg

The principal pathways by which disposal of waste at Drigg may affect the public are through resuspension of activity into the atmosphere during tipping operations, and through contamination of surface or groundwater draining from the site. Monitoring of the air at Drigg has shown that the disposal operations do not give rise to any measurable airborne activity(26). Measurements on the water in the stream at the Drigg site boundary do show that radioactivity is present. However, the stream is not used as a source of drinking water for humans, and the activity levels are such that cattle can use the stream freely(26). Thus at present, the radiological impact on the public of disposal of LLW at Drigg is very low indeed.

4.3.2 Sea Dumping

Research on and surveillance of the N.E. Atlantic dump site is carried out through an international programme co-ordinated by the NEA(27). The suitability of the site for continued use is reviewed at five yearly intervals. A review is in progress at present and it has involved both the compilation and examination of all the available monitoring data, and an extensive modelling exercise to produce improved estimates of doses to man and to marine organisms. The monitoring data show that in seawater, sediments and biological materials the radionuclide concentrations are generally very close to the levels which would be expected from atmospheric weapons test fallout and from natural background radiation. Estimates of the radiological impact of sea dumping are therefore based on calculations using predictive mathematical models. Results available at the time of writing this paper indicate that the maximum dose to any individual from past sea dumping operations is about 0.8 u Sv (i.e. about 0.04% of the average annual dose due to natural background)(28).

4.4 Summary

The information given above shows that, with one exception, the radiological impact of present UK waste disposal operations, as expressed in terms of the annual average dose to members of the public, the maximum dose to any individual, or the collective dose integrated over time, is, by any standards, very small. The exception is the discharge of liquid effluents from the Sellafield site. In absolute, numerical terms the risks to the public from these discharges are not high. Nevertheless, they are above the levels which are regarded as acceptable when continued over several years and thus measures are being taken to reduce the discharges substantially.

5. FUTURE WASTE DISPOSAL PRACTICES

Over the past few years NRPB has carried out several assessments of possible future waste disposal practices(29-35). These have necessarily been predictive studies, in which mathematical models are used to estimate the possible doses and risks to members of the public from various disposal methods for HLW and ILW. All the studies have been generic, because when they were carried out no sites which are potentially suitable for waste disposal had been announced. During the course of this work, mathematical models have been continually improved, with the aim of bringing them to the stage where comprehensive, site specific assessments can be performed. In addition, data have gradually been accumulated from research programmes carried out in the UK and elsewhere by various organisations.

The situation now is that the capability exists to perform the type of assessments needed before future disposal decisions are taken. What is lacking is the site specific information which can only be gained through detailed investigations. From NRPB's point of view this is the main "problem" in radioactive waste disposal. There is little doubt that the technology to dispose of wastes exists. However, it is not possible to take decisions on exactly where and how disposal of particular types of waste should take place until comprehensive radiological assessments have been carried out.

6. CONCLUSIONS

Of the four topics listed at the beginning of this paper, the one which has not yet been discussed is the availability of information to the public. One of the purposes in writing the paper was to provide some of this information, and to point to other sources where it can be found. Radioactive waste management is a technically complex subject, and one on which it is particularly difficult to provide information in a straightforward and easily digestible form. All too often what emerges is either too simplified to be useful or too detailed to be assimilated. However, the situation is improving and the public can help by asking questions. They can also help by remembering that even if the UK nuclear industry were closed down immediately, it would still be necessary to dispose of the wastes which have been produced over the last 35 years. Thus, the "problems" of radioactive waste disposal are not ones which can be avoided, they have to be resolved - if possible to the satisfaction of everyone concerned.

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Table 1 - Solid Radioactive Wastes

Category and Definition	Types of Materials
High-Level or Heat Generating Wastes (HLW or HGW) - Wastes in which the temperature may rise significantly as a result of their radioactivity, so that this factor has to be taken into account in designing storage and disposal facilities	Vitrified, first cycle reprocessing wastes. Spent fuel.
Intermediate Level Wastes (ILW) - Wastes with radioactivity above those of low level wastes but which do not require heating to be taken into account in the design of storage or disposal facilities	Ion exchange materials. Sludges from fuel storage ponds. Concentrates from liquid waste treatment. Fuel cladding. Plutonium contaminated materials.
Low Level Wastes (LLW) - Wastes containing radioactive materials other than those acceptable for dustbin disposal(4), but not exceeding 4 GBq t^{-1} alpha activity (about 100 mCi t^{-1}) or 12 GBq t^{-1} beta/gamma activity (about 300 mCi t^{-1})	Paper Clothing Laboratory equipment Soils Building rubble

Source: reference (3)

Table 2 - UK Arisings of Solid Wastes

Waste Type	Arisings (M tonnes)	
Radioactive waste		
- low level	1.0	total to year 2000
- intermediate level	0.16	
- high level	0.004	
Industrial wastes containing hazardous materials	5-10 per year	
Spoil from coal mining	50 per year	
Refuse (England and Wales)	28 per year	

Source: reference (3)

Table 3 - Dose and Risk Limits and Objectives for Members of the Public

Dose Limit and Objectives (recommended by ICRP and endorsed for UK use by NRPB)	Risk Objectives for Solid Waste Disposal (NRPB recommendations)
Limits	
5 mSv per year (effective dose, whole body)	10^{-4} in a year (1 in 10,000)
50 mSv per year (dose to single organs)	
Objective	
1 mSv per year (effective dose, whole body, prolonged exposures)	2.10^{-5} in a year (2 in 100,000), where doses are incurred over 10 years or more

Note

The average annual individual dose from natural background radiation in the UK is about 2 mSv, the corresponding risk is 4.10^{-5} in a year.

Table 4 - Radiological Impact of Routine Discharges to Atmosphere

Organisation	Establishment	Collective dose commitment (man Sv)	Maximum individual dose (% ICRP limit)	Critical exposure pathway (individuals)
UKAEA	AERE Harwell	$4.7\ 10^{-1}$	< 3	Milk consumption
	DNPDE	$5.2\ 10^{-3}$	< 6	
	AEE Winfrith	$2.5\ 10^{-1}$	< 4	
	Total	$7.3\ 10^{-1}$		
BNF plc	Springfields	$4.6\ 10^{-1}$	< 0.1	
	Capenhurst	$1.5\ 10^{-3}$	very small	
	Sellafield	3.7	< 4.5	Ingestion
	Chapelcross	$1.6\ 10^{-1}$	< 1	Ingestion
	Total	4.3		
CEGB/SSEB	Berkeley	$7.9\ 10^{-1}$	< 3	External
	Bradwell	$5.7\ 10^{-1}$		
	Hinkley 'A'	$7.3\ 10^{-1}$		
	Trawsfynydd	$6.1\ 10^{-1}$		
	Dungeness 'A'	$4.2\ 10^{-1}$		
	Sizewell 'A'	$5.2\ 10^{-1}$		
	Oldbury	$7.3\ 10^{-1}$		
	Wylfa	$4.5\ 10^{-1}$		
	Hunterston 'A'	$6.1\ 10^{-1}$		
	Hinkley 'B'	1.4		
	Hunterston 'B'	1.4		
	Total	8.2		
Amersham International	Amersham	$5.6\ 10^{-1}$	< 5	Milk consumption
Total		$1.4\ 10^{1}$		

Notes

Taken from reference (21), refers to discharges in 1978

Table 5 - Radiological Impact of Sellafield Liquid Discharges

Year of discharge	Collective dose commitment (man Sv)	Maximum individual dose (% ICRP limit)
1978	152	39*
1979	101	
1980	103	
1981	95	69
1982	73	60
1983	+	52

*Corrected from published estimates, allowing for the increase in dose per unit intake from plutonium

+Being calculated

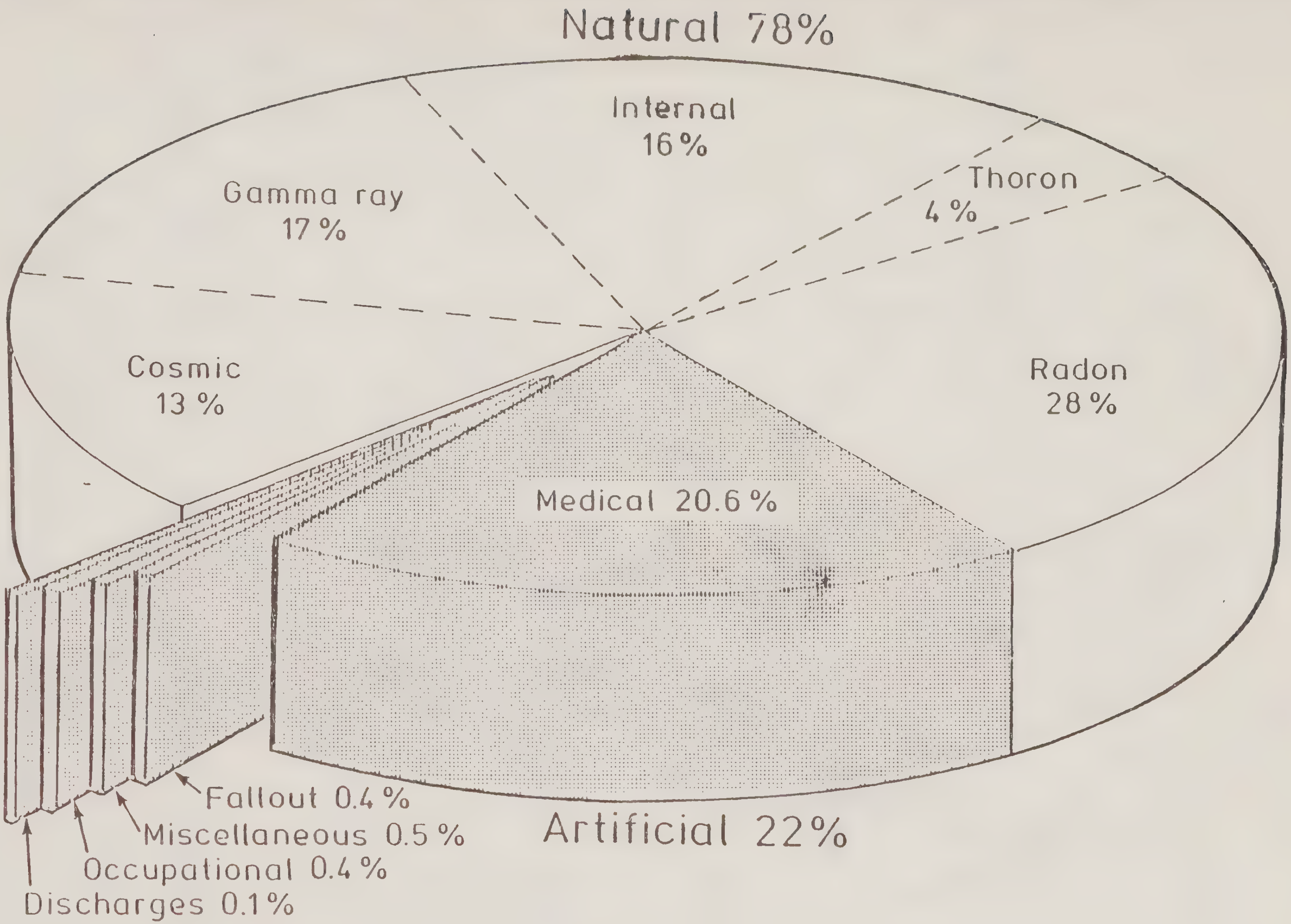

Figure 1 Contributions to Average Annual Radiation Doses to Individuals in the UK

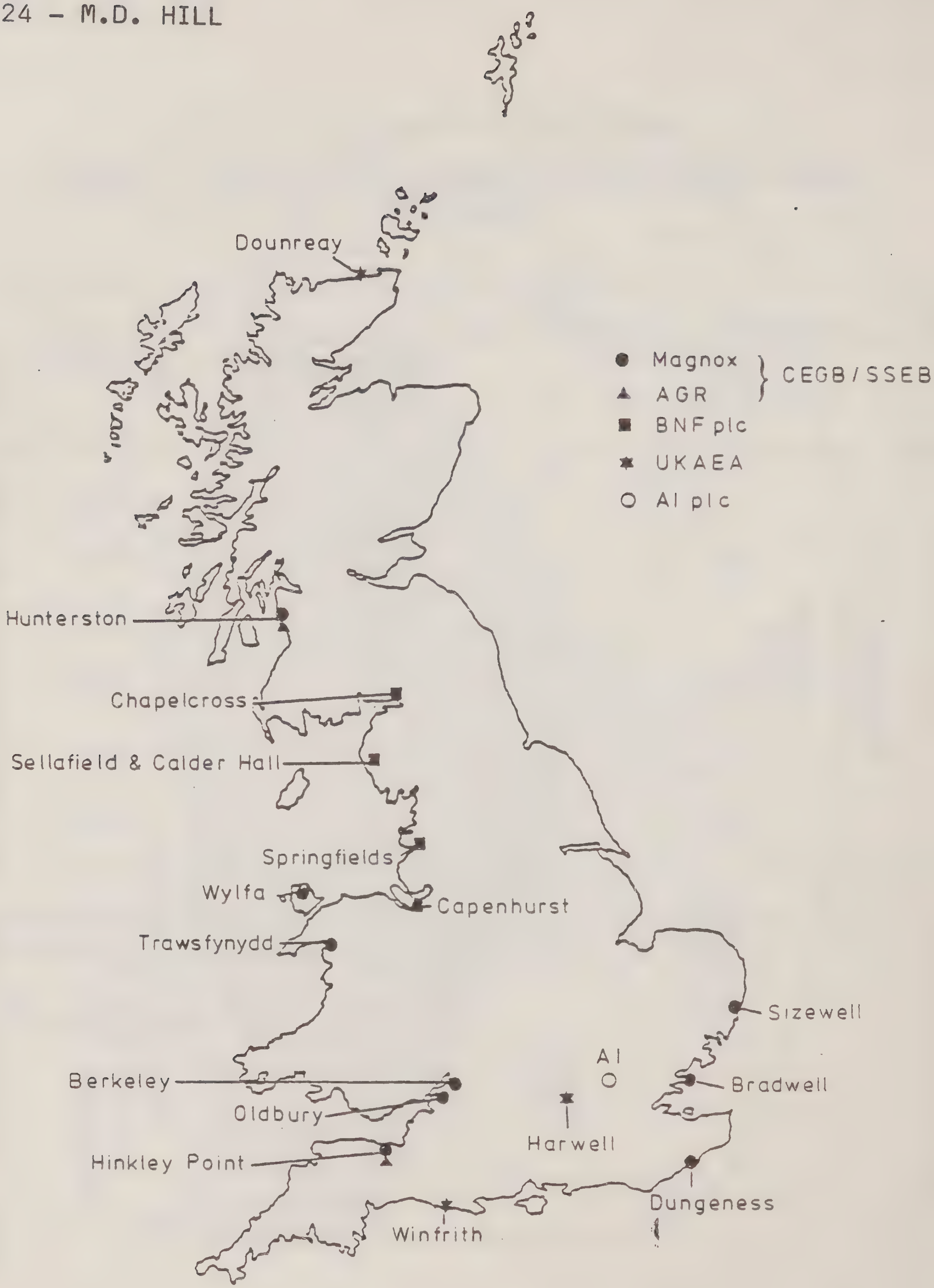

Figure 2 Nuclear Industry Installations in the UK

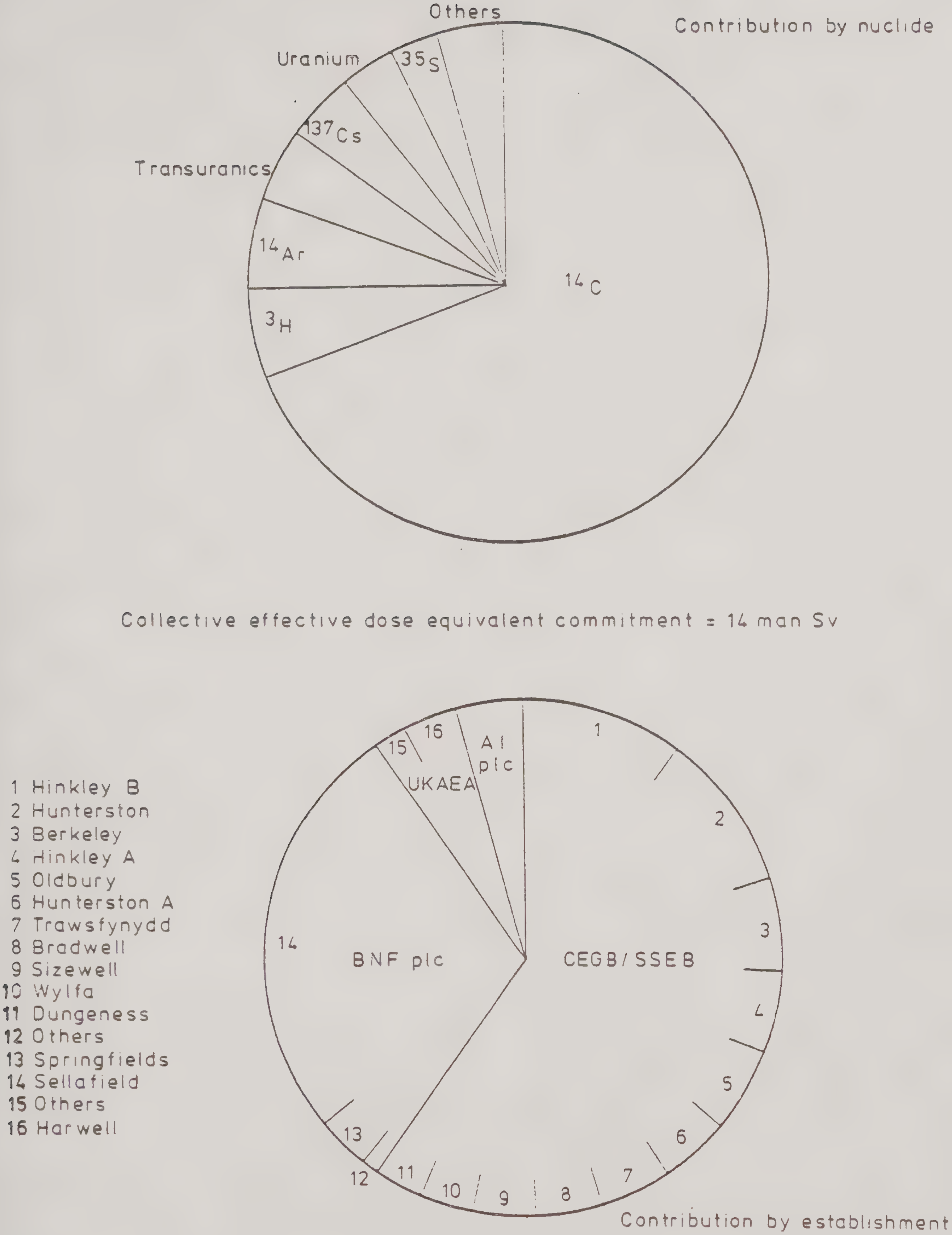

Figure 3 Contributions to Total Collective Dose Commitment to the UK Population from Airborne Effluents

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Report of Discussions

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SESSION TWO

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BRITISH AND EUROPEAN AIR POLLUTION CONTROL POLICY

Dr. M.W. Holdgate, Department of the Environment

MR. A. ARCHER, MBE (Vice-President, NSCA), opening the discussion, said that the two excellent presentations had been truly complementary. Ken Collins had given the audience a background description of the European scene and Dr. Holdgate had packed into his presentation some key issues which Mr. Archer considered worthy of consideration at every level: Community, international, national and local. There was a growing awareness that pollution problems were no longer related to single, dramatic incidents. People also recognised that the sum total of pollution presented a steadily increasing risk to man and his environment. The UK had responded, in 1970, by setting up the standing Royal Commission on Environmental Pollution and the paragraph in the first report, issued in 1971, was particularly relevant.

> "Failing deliberate measures to control pollution and to repair past damage, there is likely to be a substantial deterioration of the environment in the years ahead and the quality of life in Britain will be correspondingly impoverished despite an appearance of greater affluence."

Seen against the background of that warning, the day's discussions appeared particularly appropriate, and Mr. Archer intended to highlight a few points that perhaps needed further elaboration.

Mr. Archer remarked that both legislation and monitoring were essential for the development of a proper pollution control policy; they were the tools for the detection and solution of problems. It was, however, important to remember that monitoring was not merely the collection of samples for analysis. The complementary and essential activity would in many cases be in-depth, in-plant inspection, to examine plant processes and housekeeping, and to inspect pollution control equipment to establish whether it was effective, efficient, suitable for its purpose and properly maintained. Increasingly, industrial plant had to include the provision of monitoring and recording equipment.

It had been said that the UK had been less than enthusiastic in its adoption of environmental policies. Mr. Archer wondered whether there was indeed truth in that statement. Dr. Holdgate had explained that national air pollution policy was under review and had expressed the hope that a consultation document would be issued by the end of 1984. However, he would not need to be reminded (although the blame was not laid at his door) that in 1979 the Government had issued a consultation paper on a review of the law of statutory nuisance. Nothing had since been heard of that particular review. Moreover, the Fifth Report of the Royal Commission on Environmental Pollution had had to wait some six years for a Government response. All that contrasted sharply with the alacrity with which the Government had accepted the recommendation of the Royal Commission on Environmental Pollution (in their 9th Report) on the phasing out of lead in petrol; indeed, on the very day that the report was issued.

Mr. Archer wondered whether that speed in response had been due to the ground swell of public opinion, or to the imminence of the general election.
He considered that the proposals emanating from the Commission in Brussels, together with the air quality standards already agreed by the European Communities, all pointed to the urgency of the need for a review of air pollution control legislation in this country. He thought it was of equal importance to re-examine

the concepts of statutory nuisance, best practicable means, best practicable environmental option, best practicable environmental timetable, and, finally, the polluter pays principle. It was important to look at the ways in which these concepts could be translated into practical tools of environmental control.

Mr. Archer wished to lend his weight to Dr. Holdgate's view that without proper monitoring and enforcement to achieve the required objectives, the process of introducing new standards for pollution control would be completely ineffective.

Successive Governments had displayed a lack of real commitment to pollution control and that attitude had also been reflected by too many local authorities in their consistent failure to implement existing legislation, imperfect though it was.

An important objective of the NSCA Conference was to stimulate action, and Mr. Archer proposed to offer one or two suggestions which might be helpful in that respect. He said first that the country urgently required a national energy policy, linked possibly to a wider Community energy policy. Pollution control could not be considered in isolation. It was necessary to take into account what our likely energy dependency would be and what relative contributions would be made by oil, gas, coal and nuclear energy. It was particularly desirable to know, in the long term, how coal would be used - whether it would be burnt raw, or used for making gas or oil or as a chemical feedstock, or for all those purposes. Mr. Archer believed such information to be essential, not least in relation to consideration of policy to abate the acid rain problem.

Secondly, he considered that there was a need for closer collaboration and co-operation between the enforcement agencies, between the Industrial Air Pollution Inspectorate and the local authority environmental health officers, and said that this might be effected by a planned interchange of staff between the two. He also thought that technical staff would benefit from closer liaison and discussion with those engaged in pollution control in other EEC Member States, or with officers in the USA or USSR, for example. Much could be learnt from such discussions.

Finally, he considered there to be a need for two or three environmental health officers with specialist skills to be attached to the Department of Environment, there to liaise with their colleagues in the districts, with local authority associations, and with expert working groups within the Commission. He was surprised that the Department of the Environment, administratively responsible for such a wide range of duties, failed to have on its staff experienced environmental health officers who could give practical advice on such diverse matters as housing, air pollution control, noise control, refuse disposal etc.

MR. T. BOYD-MEANEY (L.B. Waltham Forest) said that Conference discussions that morning had concerned the macro environment. Indeed, he considered that the whole programme was geared to that end. However, what had emerged from the proceedings so far, was that the solutions being proposed lay almost entirely within the European Community. However, Mr. Boyd-Meaney said that he had recently returned from a visit to Poland, and the problems that they experienced with air pollution were just as acute. Forest die-back was occurring in north west Poland (an extensively forested region, and Polish feelings about their forests were as strong as those held in Germany). While he thought that some of the damage was due to afforestation policies, he had seen industrial air pollution on an extensive scale, which would be quite unacceptable in the UK. He felt that some of the die-back was due to acidic deposition. He asked the speakers whether they could tell him what was actually being done to control air pollution and acidic deposition in the eastern European countries, notably East Germany, Poland and the USSR. He wanted first to know what was being done in those countries on a national basis, and secondly, since the problem was a transboundary one, what the eastern bloc countries and the members of the European Community were doing together to look at the problem from a truly European perspective.

DR. M.W. HOLDGATE, replying, said that the eastern European countries were signatories to the UNECE convention on long range transboundary air pollution, and had participated in the two meetings of the Executive body, held during the past two years. Seven or eight of the eastern bloc countries had already committed themselves to the "30% Club". Thus, they had accepted a commitment to reduce their sulphur dioxide emissions by 30% by either 1993 or 1995. Amongst those countries was the USSR. That country's pledge was of particular interest. Their commitment was to reduce by 30% the sulphur oxide flux across their western boundaries. That was an important pledge, since the USSR emitted some 25 million tonnes of sulphur dioxide, but only about one million tonnes travelled west over the border. The USSR was re-equipping its power stations in the western part of its territory to burn natural gas, of which, of course, the country has an abundance. The USSR was also going nuclear, on quite a substantial scale. Such plans were not being made for the whole of the country, but this limited retrofit would enable them to reduce, by 30%, the SO_2 flux across their western boundary. Another option being considered in the USSR was to switch motor vehicles to liquid natural gas propulsion.

In summary, quite a lot was being done, nation by nation, in eastern Europe. Poland had particular difficulties because of its economic situation. The DDR and Czechoslovakia were moving forward on sulphur dioxide, but were much more reticent on nitrogen oxides.

Dr. Holdgate said that he had also been on the frontier between Czechoslovakia and the Federal Republic of Germany, and there was clearly acute damage to forests in that area also, attributable to drift from the east. It was impossible to clear up the problems in German forests without tackling emissions from the east, but Dr. Holdgate thought that that had been recognised. The eastern countries were co-operating.

MR. KEN COLLINS, MEP, replying, wished to reinforce something that Dr. Holdgate had said earlier in his presentation, that, while the UK was a member of the European Community and the European Community was active in promoting action to control acid deposition, the story did not end there. It did not begin there, either. Mr. Collins said that it was important to realise that the Community was part of the wider international concern via the United Nations Economic Commission for Europe, the Community being also a signatory to the Convention. However, Mr. Collins felt that national initiatives were also important. It had to be recognised that there was a scale of operation, and that it was essential for countries to be active at each level of the scale. It would be wrong either to confine action to the national level, or to wait for international moves before acting. The whole range of activity had to be embraced.

MR. D. BIRD (Yorkshire and Humberside Division, NSCA and Sheffield City Council) had a number of questions, the first of which was on the availability of resources.

He asked Mr. Collins for his opinion on how resources were used by the CEGB, particularly since the CEGB seemed to expend a great deal of money and energy on publicity to explain in detail why they were not taking any action to abate emissions.

The second, related, point concerned the work of the DOE's Noise and Air Pollution Division. All local authorities accepted that the Division was under staffed and over worked which, he felt, reflected the lack of political commitment to the environment as a whole. Mr. Bird wondered how the Air and Noise Division managed, with its small number of staff, to determine how to split its resources between attempting to influence European policy, and its commitment to sorting out domestic policies, and then managing to link the two together.

Another question of resources had been raised by Dr. Holdgate's remarks about monitoring and enforcement. Mr. Bird wondered how local authorities, many of whom faced stringent restraints on spending, would be able to meet this commitment.

David Bird did not quite agree with Dr. Holdgate's evaluation of risk assessment. He considered that the concern expressed by the public over nuclear waste was a rather truer reflection of the risk involved than Dr. Holdgate had indicated. He was concerned that policies reflected an "environmental dustbin" approach, and he questioned the validity of the research on which such policies were based. Cynics would say, he felt, that when Government wished to adopt a policy such as dumping nuclear waste at sea, the research always pointed to a nil effect, with statements such as, "The sea has infinite capacity for small amounts of nuclear waste". However, where a policy appeared undesirable, such as the removal of sulphur from flue gases, the scientific evidence always appeared to be uncertain.

Finally, Mr. Bird expressed amused amazement at the way politicians (he regarded Dr. Holdgate as one of the most consummate politicians he had ever heard) always managed to turn issues on their head. Saying that many delegates would remember the attitude of the British Government towards lead in petrol, he reminded the audience of the influence of a certain pressure group who were CLEARly ahead in pushing the lead in petrol debate in this country, while amongst the EEC Member States, FRG had taken the lead on this issue. Somehow, this had been metamorphosed into a UK initiative, in Dr. Holdgate's words.

MR. COLLINS, replying, picked up first on the point about the CEGB's publicity, although he noted that it was not just that organisation which had been publicising their views on the issue of acid rain. He felt that all sides were in some difficulty on the issue, because they were operating on the meeting point between rational science and irrational politics. Therein lay the weakness of the Central Electricity Generating Board.
Mr. Collins considered that they had many excellent scientists working for them, but he was unsure that those in the GEGB understood the political process at all and he felt it was about time that they did so. He was suspicious of anyone who held absolute views on the issue; certainty seemed to him quite impossible at this stage. He shared Mr. Bird's concern about the CEGB's publicity, and agreed that it was possible that the CEGB believed its own publicity.

Referring to the comments about the small Division within DOE responsible for Air and Noise Pollution, Ken Collins said that part of the problem was that the Department was not really a Department for the Environment at all, it was a Department of local government. As a result, there were very good people working within the Department on both civil service and the political side - for example, he thought William Waldegrave a Minister with his heart and his head thoroughly in the right place on environmental issues, but in reality he spent a lot of his time having to deal with problems such as rate-capping. It was necessary to look very carefully at the structure within DOE, and to consider whether it served its purpose or not. As Mr. Archer had pointed out earlier on, the environment had to be viewed in a much wider context, for example in relation to agriculture or energy policy. So long as those issues were isolated, it was difficult to deal with them properly. As an aside, he said that he appreciated the fact that Mr. Waldegrave had recently set up a joint committee to deal with issues involving the environment and agriculture. Nevertheless, he considered that the present structure militated against sensible and rational policy-making.

Lack of policy commitment by Government to the environment was not confined solely to the UK. For example, most people agreed that environment policy at EEC level was important, and would assume increasing importance in the future. As rapporteur for the Environment Committee of the European Parliament on the discussion for the 1985 budget, Ken Collins was very concerned that the lines (and there were only 39 of them) and work on environmental policy only accounted for less than 1% total Community spending. It wasn't the case that Community environmental policy was considered unimportant, but that other policies, some of which were actually environmentally damaging, had grabbed the lion's share of attention. The Community itself did not link energy, agriculture and the environment etc together in the way that it should. Mr. Collins considered that it was necessary to forge the links between these policies to create the kind of structure that was desirable.

Replying finally to Mr. Bird's somewhat acid comments about lead in petrol, Mr. Collins said that the true story of lead in petrol was even longer than most people suspected. The first resolution on lead in petrol had been tabled within the European Parliament three years earlier, in March 1981. It had been tabled by Mr. Collins and by Horst Seefeld, Chairman of the Transport Committee. These ideas had been taken up by a certain British pressure group, some six months later. The linking of the European

Environmental Bureau and BEUC had come later on, as a result of work by the Committee of which he was Chairman. Mr. Collins considered that, to some extent, Britain had led the way on the issue within Europe. Britain had in fact acted in tandem with FRG. Commenting on Mr. Archer's earlier remarks, Mr. Collins said that his view was that had not the Royal Commission report and an impending election so favourably coincided, the UK's provision on lead in petrol might have been very different.

DR. HOLDGATE, replying, wished to put on record the fact that, as a scientist himself, he had the highest regard for the scientific ability and integrity of those scientists working for the CEGB whom he had personally encountered.

Turning to the comments on the Department of the Environment, Dr. Holdgate said that his own responsibility was for that part of DOE which was truly concerned with environmental protection. He agreed, however, with Mr. Bird's remark, and said that his colleagues in the Air and Noise Division would also warmly support the remarks made. The Division was under enormous pressure of work, and did not have the staff to do all the things they wished to do or all the things which Dr. Holdgate himself would want to do. He had some good news. Steps were being taken to strengthen the scientific ability of the Division, to the tune of one scientist on secondment from the meteorological office, and, hopefully, another to be appointed shortly. However, Dr. Holdgate said that it would be wrong to imagine that the Division worked in isolation. It was able to consult and receive scientific advice from those outside the Department, and research was commissioned which would be of use to the Division. People might feel that as yet there was an inadequate amount of research being commissioned by the Department, but the level of research had been increased over the past two years, and Dr. Holdgate believed that this trend would continue. The Division was also helped by other Departments within DOE, notably by the International Affairs Division, which, like the Air and

Noise Division, was a part of the Central Directorate on Environmental Protection. Granted more resources, Dr. Holdgate could guarantee that that Division would do more, but attention was already being paid to its needs.

Speaking specifically about the Division's determination of its priorities and division of activities, Dr. Holdgate said that it had to act responsively as well as responsibly. Some of the tasks had to be ad hoc, arising out of international discussion, or the needs of Ministers (because, after all, the Department was run for Ministers).

Dr. Holdgate apologised for the fact that the Consultative paper to which he had referred (on the review of air pollution legislation in the UK) had taken longer to produce than had originally been promised. The delay had been partly due to one or two recent developments which had taken up considerable staff time.

Dr. Holdgate excused himself from commenting on the adequacy of local authority resources to meet the tasks which both he and Mr. Bird agreed were desirable.
Turning to the subject of risk assessment, he felt that there was an extremely important point about the public's perception of risk, which was well illustrated by the nuclear debate. He said that the public was frightened by much that was written about the risks from nuclear substances. A ship had gone down off the Belgian coast a few weeks before, and it had been carrying uranium hexafluoride. The radioactivity of that material was very little different from the radioactivity of Aberdeen granite, yet, because it was a so-called nuclear substance, a great deal of public anxiety had been aroused.
Dr. Holdgate considered it useless to winge or gripe about the level of public concern. That concern was a fact, and would only be allayed if scientic facts were presented in a fashion that the public believed to be truthful and honest. It was the duty of professionals to convey such information in the most open way, and there was no substitute for such honesty.

That last point touched upon the comment David Bird had made in relation to the certainty of evidence, when something appeared desirable, and the allegations of lack of evidence when an authority did not want to do something. Dr. Holdgate felt that there was a measure of truth in the assertion, and said that it was something that had been recognised by the Council for Science and Society which was considering the matter. The short answer was that scientific evidence could legitimately be deployed to make a case, so long as it was clear that this was what was being done and so long as the facts were not distorted.

Turning finally to the subject of lead, Dr. Holdgate said that whether or not Her Majesty's Government had come to the decision on lead in petrol later than certain other components of the Community it was a fact that it was a British Government memorandum to the Presidency that brought the need for urgent action before the last Environment Council. That illustrated how member Governments could take initiatives, without waiting for the Commission.

BARONESS WHITE (House of Lords) said that, together with Lord Cranbrook, she was a Member of the House of Lords Select Committee on the European Communities which had recently reported on air pollution, following their examination of the recent proposals of the European Commission. As might have been expected, the Lords had been somewhat more cautious in their recommendations than the House of Commons Select Committee had been in their later report. It was the business of the Other Place to be enthusiastic, and that of the Lords to be rational and statesmanlike! The real reason for the Lords' Committee's caution had been because of their genuine puzzlement in the face of the timescales (or lack of them) included in the evidence of some of the witnesses to the Committee, notably the National Coal Board. The NCB had drawn the Committee's attention to the potential of pressurized fluidised bed combustion for coal, but without giving a reliable timescale which could convince the Committee of the validity of the NCB's presumption (about the viability of the technique).

The Committee had considered that the politics were such that neither the UK, nor any other part of the European Community, could simply wait for the technologists and scientists to come up with the perfect solution, meanwhile doing nothing. Hence the Committee had recommended interim action, even at some cost to the CEGB, this action to be taken in the much nearer future than was conceivable from the suggestions for preferred solutions put forward by the CEGB or NCB. Nevertheless, the Lords' Committee had taken the suggestions made by the CEGB and NCB more respectfully than had the House of Commons. It was debatable as to which was in the right.

Lady White entirely agreed with Dr. Holdgate's remark that environment was now a component of diplomacy. A few years earlier, such comment would have been greeted with scepticism, but since then there had been a change. There had been a change in, of all areas, agriculture. From the environmental points of view, this had been greatly helped by the crisis in agricultural support, agricultural quotas and other economic factors, which had had a tremendous influence on agricultural leaders in the UK and elsewhere during the past few months. Just a few weeks earlier the Country Landowners Association had issued a statement claiming that its members were all splendid environmentalists, which would have been unthinkable even two years before. As yet, there had not been a comparable conversion within the CBI or the CEGB, or indeed the NCB. Until such a conversion took place, it would continue to be difficult for the UK's representatives within the European Parliament, on the Commission, or even on the Council of Ministers, to convince our European allies that the UK is truly dedicated to those environmental ideals which Lady White believed were held by many people in the UK.

Referring to the Stuttgart summit, Lady White expressed the belief that Chancellor Kohl had almost certainly had some influence with Mrs. Thatcher, in pointing out to her that certain votes might have green edges. By that she did not mean to suggest that the UK should follow the political pattern of West Germany with a separate Green Party; she did not believe that this would suit the temperament or practice of those in the UK at all.

Lady White considered that it was the responsibility of those in the UK (such as the delegates to the NSCA Conference), who cared about the environment, to bring pressure to bear on Government in order to achieve desirable objectives. She wondered how Martin Holdgate could defend the UK's record, when, ten years after it had been passed, sections of the Control of Pollution Act 1974 were still unimplemented. The relatively simple problems of waste disposal by local authorities, for example, still remained to be solved. In Wales, where the District Councils were the disposal authorities, no authority had yet prepared adequate waste disposal plans. In another crucial policy area, the Commission on Energy and the Environment had been dumped after one report. In relation to acid deposition, energy policy was of paramount importance, and yet their one study (with a report priced at £23.00, so that no ordinary democrat could afford it!) had been considered to be sufficient. It was these inadequacies which created the poor image that the UK had in Brussels, or, for that matter, in Strasbourg. Thus, it really was up to concerned individuals, not necessarily to go overboard in forming green parties, but to continue to convince the politicians that there was mileage for them in espousing sensible and sensitive environmental policies. Without such a conviction, politicians would not uphold the policies, or spend the money, or give central or local government adequate resources, to control environmental pollution. As well as being rational and convincing, people had to have some political nous and clout, which had been sadly lacking in earlier days.

MR. R.I. KEY (Worcester City Council) wished to echo a comment made by Mr. Archer earlier in the Session. He said that he was quite concerned, as many other of the delegates might be, about the lack of implementation of domestic smoke control policies by a number of urban authorities which had pollution hot spots in their areas. He wondered when the Department of the Environment would take positive steps to force domestic smoke control on to those laggard local authorities.

MR. M.J. GITTINS (Leeds City Council), speaking as the regular environmental correspondent for the IEHO, said that he found it relatively easy to find out what was going on within DOE. He also found that the OECD had very effective communication with accredited columnists on environmental matters. However, he found it extraordinarily difficult to obtain information or briefings from the European Commission in Brussels. He had written to the secretariats of the various Committees; the correspondence had been passed on to other departments, and sometimes his letters had been totally ignored. He had not been at all surprised by Mr. Collins' remarks about his colleagues' experience with bank managers. It was not surprising that most people in the UK knew little about the workings of the European Commission, or its policies. He regretted the fact that the European Commission did not see fit to allocate greater resources towards the task of informing interested individuals about their policies and proposals.

MR. COLLINS, replying to Mr. Gittins' point, said that the situation was variable. Many people would say that in most respects, the Commission was far more open than, for example, Whitehall. Nobody within the Commission bothered too much about secrecy; in fact, it was the leakiest governmental organisation which Mr. Collins himself had ever encountered. If anyone wanted to read a particular paper, it could either be obtained officially, or simply found left lying around! Any difficulties that there were in obtaining information arose from the fact that not everyone was aware of whom they should contact, or when, or where. However, once that personal contact had been established, information was readily obtainable.

As he had noted in his address, Mr. Collins' own reservation about the Commission's operations related to the consultation process. The worst example he could recall was the draft directive on environmental impact assessment. That had gone through 23 drafts before the official version was published. Many people had been consulted during the 23 draft stages, but it was not clear whether everyone who had been consulted, had been consulted at each and every stage. Nor was it clear in what order people were taken into the confidence of the Commission. Inevitably, that raised doubts about whether or not the Commission sought to achieve a desired objective by simply engineering the order of consultation.

Mr. Collins said that he was frequently approached by various groups, sometimes of environmentalists, sometimes from the industrial side, who told him that they had given evidence to the Commission, but that it did not appear to have been taken into account in the published proposal. Until the Commission was prepared to publish details of whom it consulted at every stage, people would continue to be dissatisfied with the process.

Commenting on domestic smoke control policy, Mr. Collins pointed out that the major political party conference took place regularly in Brighton and Blackpool. While Brighton had five smoke control areas, the programme had not yet been completed, and Blackpool did not have a programme. Mr. Collins thought that this might be a point worth pursuing.

Turning to Lady White's comments about the need for the CBI and CEGB to modify their attitude towards the environment, Mr. Collins said that in his opinion the attitude of the CBI was extremely worrying. It was, constantly, a terribly defensive attitude. After four years of argument, his Committee had finally persuaded the CBI to meet with them. He recalled, in the early days of the European Parliament, visiting the CBI's old offices and having furious arguments with the Confederation's representatives about the methods of lobbying that they were employing. There were many useful methods of persuasion and lobbying that could be used to convince other organisations and other Governments of the justice of one's position. To issue gratuitous insults aimed at people presenting papers etc. was not one of those ways. Instead, it was certain to ensure that one would be completely isolated. Mr. Collins considered that the CBI was beginning to learn that lesson, but it had taken four hard years of argument to teach them. Until the UK's industrial lobby was prepared to adopt a more sensitive approach, even a Minister such as William Waldegrave would have a very uphill task to convince his colleagues and the rest of the Community of Britain's good intentions.

DR HOLDGATE, in response to the comment made by Lady White on the enforcement of legislation and on the fulfillment of commitments made by governments. agreed that there were disparities, which he had seen in an acute form that year in the UN Environment Programme's review of desertification. Governments of many nations could deplore the loss of some 20 million hectares a year of productive land, and pass resolutions to adopt rational policies which would put an end to the process - yet, at the end of it all, the process of desertification was not arrested. Nothing happened because many of the signatory governments lacked either the means or the will to implement the rational strategy.

However, he considered that the situation was better within Europe, and certainly in the UK. Governments did not, in his opinion, legislate without the intention to implement the legislation. What did occasionally happen was that the timing of implementation was altered, partly because of a change in the perception of need, and partly because of what appeared to be valid reasons for delay which emerged after the legislation was passed. Nonetheless, he considered that there was a closer link between the legislative and the operative system in the UK, and by and large in Europe, than existed in many other parts of the world.

Referring to the comments about the Commission of the European Communities, Dr. Holdgate said that he found it a rather diffuse body, with the various Directorates General appearing sometimes to operate quite apart from each other, and without much communication. Even individuals within the Commission's Secretariat appeared sometimes to be developing their own lines right up to the point where proposals were written into papers for the Council.

He agreed with Mr. Collins that it was also sometimes difficult to work out how the analytical process had been conducted. In the UK, that had troubled the Royal Society, which had attempted to set up an investigative Committee with the other Academies of Science in the Member States of the Community, to see whether the best scientific knowledge in those countries could be linked through to the formulation of Community policy in a more structured way, ensuring that the best scientists (who had the confidence of their peers in their own country) would be brought into the advisory system. The Royal Society's initiative had resulted in two international meetings, and some considerable contacts with the Commission. The exercise had run somewhat into the sands, which Dr. Holdgate considered to be unfortunate. He felt that to line up national experts in a more visible way to assist the Commission in their thinking, would help to improve the clarity and cohesion of the process which resulted in proposals from the Commission. If that happened, it would have the added benefit of improving national understanding of the way the proposals were developed.

DR. L.A. CLARENBURG (SICOM, The Netherlands) considered that Dr. Holdgate had stressed the importance of harmonisation, since his address had begun on that note and the topic had reappeared in his conclusions. As Dr. Clarenburg further understood it from Dr. Holdgate's description, at the meeting in Geneva the previous week the representatives of various countries present had agreed to the "aim of policy" to reduce oxides of nitrogen and oxides of sulphur by 30% by the year 2000.

Dr. Clarenburg said that this proposal was hardly compatible with the desire for harmonisation. A blanket 30% reduction would impose greater strains on one country than on another. For example, it would be easier for the UK, with an older industrial base, to achieve a reduction of 30% in sulphur emissions, than it would be for his own country with its relatively new industries.

Dr. Clarenburg asked whether the goal of harmonisation would not be better served by setting limits in terms of the permissible emission per unit of production of a given product, and (as in the Japanese legislation) make this decreasing in time. He asked Mr. Collins what definition of harmonisation he would prefer. Dr. Holdgate had noted in his address that the centre of operation was already shifting from Brussels to a yet wider international scale. Dr. Clarenburg expressed the hope that some momentum would remain in Brussels, since he felt that this was the proper place in which to achieve true harmonisation in Europe.

DR. R.A. BARNES (Esso Research) said that Mr. Collins had laid great emphasis on the need to take action against acid deposition before scientific certainty was achieved. Dr. Barnes asked Mr. Collins whether he was aware of the fact that a considerable degree of certainty had already been achieved. In particular, it was clear that different control strategies were required to deal with different environmental targets. For example, building corrosion was best abated by reducing local low and medium level emissions, whereas the freshwater ecology in Scandinavia would be protected most easily by controlling tall stack emissions in specific geographic locations. He asked Mr. Collins how he would rank the various action targets in terms of priority, in view of the political, not scientific, decision that was required before any useful abatement action could be made.

CLLR. L. HARRISON (Wakefield MBC), returning to the theme of domestic smoke control raised by earlier speakers, and linking it with the point about risk assessment said that his Chairman was a living example of the latter in relation to the former! He was a member of the NUM Committee, a member of the local Council, in an area in which many people received a concessionary coal allowance. His risk factor in attempting to introduce smoke control was of a considerable order!

He congratulated Lady White for her exemplary grasp of the issues, and reminded Dr. Holdgate that pollution was not an abstract concept but was about individuals and their quality of life. Within the wider European context or even on a national basis, Yorkshire appeared to have been left behind. People in Yorkshire could not afford to be concerned about forests. They were still concerned with the basic problem of emissions from domestic chimneys and the quality of the air that they breathed.

He thought it might help to strengthen the case for smoke control if scientists could only find some significantly worrying element of radioactivity in coal smoke. That would ensure that the emissions disappeared overnight. Everyone was worried about radioactivity, but Cllr. Harrison said that it did not concern him whether he died of radioactivity or bronchitis - he would be just as dead in either event. Somehow, though, it appeared to be more acceptable nowadays to die of bronchitis than to die of long-term exposure to radioactivity. And yet, people had been dying in Yorkshire of bronchitis for years. More education on the risks attached to old fashioned coal burning was still required.

In view of the high political risk attached to the voluntary introduction of smoke control in mining areas, Cllr. Harrison asked why the Secretary of State for the Environment could not make use of his powers to force local authorities to introduce smoke control, and make available the necessary resources to provide for the grant expenditure.

MR. COLLINS, replying, said that the points made by the previous three speakers were to some degree related.

First, on the question of harmonisation, when the European Parliament had held their hearing on air pollution and acid rain, one and a half years earlier, they had had to turn their minds to the basis for the Community's environmental policy. Theoretically, that policy was not justified by the Treaty of Rome. Two conclusions could be drawn from that. One, a politically important conclusion, was that the environmental policy was living denial of the view that if something was not in the Treaty of Rome, it could not be done by the Community. Thus, it could be seen that with political will and political guts, there was no reason why one could not persuade the Community to move in the direction you saw as desirable. The second conclusion was that environmental policy had been arrived at via the back door, that is, via consideration of competition policy. The reasoning was that companies and countries should not be put at a competitive disadvantage by virtue of differing levels of environmental control in the various Member States.

In that connection, Mr. Collins said that Dr. Clarenburg's comment that a 30% reduction would affect countries unevenly was an important and valid point. Nigel Haigh of IEEP had presented to a previous NSCA Workshop a table showing how a given reduction in emissions could be calculated and distributed in different ways. The conclusions of the (Dutch) rapporteur at the European

Parliament hearing on acid rain had in fact been strongly in favour of emission control rather than percentage reductions.

Another point made by Nigel Haigh, and echoed that day by Dr. Holdgate, brought out the real difficulty of supra-national action in the area of controls aimed at reducing acid deposition. Within each country, the institutions of government that are able to decide on policy, enforce and monitor it, are also those institutions which allocate costs within the country. Thus, if the problems were confined within national boundaries, the decisions as to controls and allocation of the costs were relatively simple and could be defined within set limits. But in the context of the European Community, the allocation of costs was more complex. The damage lay in one area, whilst the bill had to be paid in quite another area. The institutions were not necessarily from the same country and therefore the same easy conformity was not possible. There was a similar problem with enforcement of legislation. The European Community, and in particular the Parliament, was in a somewhat ambivalent position (in the sense that many people were ambivalent about the role of the Parliament). People's attitude towards the Community depended very much on whether they wanted something to be done or not. If they desperately wanted something to be done, they would call for the European Community to take the lead; but if not, they would say that the European Community was interfering in something in which it had no business. It was actually impossible to have it both ways; a balance had to be struck between the need to maintain the national right to implement legislation and enforce it, and a nation's international obligations. People had to sort out in their minds whether or not they wanted the European Community to have any sovereign power or not.

Turning to Dr. Barnes' question, he said that his Committee was in the course of producing a report for the European Parliament on the Major Combustion Plant proposals, and that he would prefer to wait for the publication of that report before making any major pronouncement on priorities to be attached to the various control options. He entirely agreed with Dr. Barnes that different targets required different control approaches but preferred not to rank those targets immediately.

DR. HOLDGATE, referring to Dr. Clarenburg's question, said that he had used the term "harmonisation" not in the technical sense, but to imply that because the approaches in the UK and in other European countries had a great deal in common, it was possible to harmonise action in a way that would not have been possible had these countries operated in quite different ways.

He considered that perhaps he had misled Dr. Clarenburg (perhaps he had been speaking too fast) about the Geneva meeting the previous week. The "aim of policy" to achieve a 30% reduction in sulphur dioxide and nitrogen oxides emissions by the end of the century had been expressed in a United Kingdom Government statement. A number of other Governments were already, of course, committed to a 30% reduction in sulphur dioxide by an earlier date, as a firm commitment, whereas the UK's was an aim of policy. Nonetheless, it had been a new statement by the British Government, and as such, he had reported it.

Turning to Cllr. Harrison's comment about the apparent irrelevance of concern about tree damage and acid deposition in Europe viewed from the perspective of Yorkshire (where the concern was for the more basic health care issues associated with urban contamination from low level sources, which could be cured by tried and tested methods) Dr. Holdgate said that while he did not like to make work for the small Air and Noise Division in DOE, he would ask them what the current situation was and would be very glad to hear any further comments on the situation from members of the Society. There was a European Directive (on health protection standards for smoke and SO_2) which related to that sort of pollution, and part of the country still did not fully comply with the limits laid down in the Directive. That had to be a matter of concern, even for Whitehall bureaucrats like himself. As one brought up in Lancashire, he appreciated Yorkshire forthrightness and Yorkshire humour. Cllr. Harrison's remarks had brought him right down to earth, with a bit of a bump.

Statement by Councillor Mrs. B. Solkhon, Chairman, Environmental Health and Control Committee, Brighton Borough Council, given to NSCA 51st Conference on Tuesday 2 October.

AERIAL CROP SPRAYING

Chairman, Distinguished Guests, Members of Conference,

On behalf of Brighton Borough Council, and the Environmental Health and Control Committee in particular, I am most grateful for the opportunity you have given me to speak on a subject which is of grave concern to the Borough Council and which, I strongly suspect, is of concern to others too.

I speak, Chairman, of the growing menace of crop spraying and I would like to illustrate the point with an account of an incident which occurred earlier this year in Brighton.

Following receipt of a number of complaints by the Council's Environmental Health Department, it was suspected that Council-owned playing fields had been contaminated by chemicals sprayed from an aircraft. We had visual evidence of spray drift falling away from the target zone and subsequent chemical analysis of grass samples revealed that the playing field had been contaminated with a herbicide containing a skin irritant.

It also came to light that vehicles on public roads and private land had been sprayed in separate incidents but there was insufficient information to enable a full investigation to be carried out in those cases.

District Councils, unbelievable as it may seem, have no controls over aerial applications of chemicals used in agriculture, horticulture and forestry. The activity is the responsibility of the Civil Aviation Authority who issue an Aerial Application Certificate to the operator although the Health and Safety Executive may carry out an investigation if the general public are affected by chemicals. And I have to say that the Health and Safety Executive have, so far, been quite unco-operative in this affair. And while I do appreciate that there is a need for some degree of confidentiality, I cannot accept that this is a sufficient reason, for the non-co-operation of the HSE, at this time, with the proper officers.

The Aerial Application Certificate signifies that the holder is "competent ..... to secure the safe operation of his aircraft". Aerial application of chemicals cannot be undertaken until and unless the operator holds a Certificate from the CAA.

When making an application for a certificate to the CAA the operator must submit an aerial application manual which must contain such information and instructions as may be necessary to enable operating staff to perform their duties safely. It should cover not only instructions and information related to the safe operation of the aircraft but also to the safe application and handling of chemicals etc.

The manual should contain specific information relating to spray drift; it should state the company's policy as regards the use of notices to warn motorists and other persons using public roads and public footpaths. The manual should also contain information relating to the duties of the ground crew, and the requirements controlling the restriction of chemicals to the target area must be quite specific.

Now, is this procedure effective in ensuring a safe operation? No it certainly is not in our experience and many of the precautions I have referred to are manifestly not carried out.

The manual should describe the operator's procedures for giving prior notification of aerial applications to persons who may be affected by them. These include:-

a) the relevant Chief Constable;

b) occupants of buildings, and owners, or their agents, of livestock or susceptible crops on land adjoining the area to be treated;

c) any hospital, school or like institution within 500 feet of the flight path;

d) the Nature Conservancy Council and

e) the local Bee Keepers Society!

All those people should be informed, but I have to tell you that no evidence of any such notifications has come to light in our investigations.

There is no requirement to notify the District Council. Why not?, I ask. Who is going to check whether the requirements of the Aerial Application Manual are being complied with? The answer is simple, Nobody!

The principle of aerial spraying, particularly adjacent to residential areas and public open spaces, must be reviewed. But, in any event there needs to be tighter legal controls over this activity generally to include local enforcement by District Councils - and heaven knows we are not seeking yet more duties and responsibilities at the present time. There must be provision for prior notification and prior approval. Existing controls are of some value, albeit after the event but revocation of Licence or suspension of the Certificate do nothing to compensate for the damage and suffering that can occur.

Mr. Chairman, it is clear to my Council that present controls over crop spraying, and aerial crop spraying in particular, are ineffective. They are not being enforced nor complied with and the public's safety is at risk in consequence.

I therefore invite Conference to give its full support to Brighton Borough Council's call for an early review of the practice with the expectation that effective controls and safeguards will be introduced, with the full force of the law behind them, at the earliest possible opportunity.

SESSION THREE

AIR POLLUTION CONTROL - SITUATION REVIEWS

AIR POLLUTION CONTROL - SITUATION REVIEWS: INCINERATORS

W. Short, National Industrial Fuel Efficiency Services Limited

AIR POLLUTION CONTROL - SITUATION REVIEWS: CHEMICAL INDUSTRY

Dr. J.T. Farquhar, Albright & Wilson Limited

INDOOR AIR POLLUTION AND ITS IMPLICATIONS FOR HUMAN HEALTH

Dr. R.J.W. Melia, Department of Community Medicine, United Medical & Dental Schools of Guy's and St. Thomas' Hospitals

MR. O.A. DODDS (Bristol City Council), opening the discussion, said that he would whole-heartedly support Councillor Solkon's call for stricter controls on aerial crop spraying. He had had personal experience of the problems, and said that he would wish all delegates to return to their authorities, make enquiries as to the situation locally if they were unsure of problems it caused, and then if possible lend their weight to Brighton's stand on the issue.

Turning to the presentation by Mr. Short on incinerators, Mr. Dodds said that he would agree that certain types of incinerator had a poor image. Regrettably, people remembered problems more than successes and judged the effectiveness of a process or a piece of equipment accordingly. Mr. Dodds wished first to ask Mr. Short a question which he could equally have put to Dr. Holdgate that morning, concerning the draft regulations on grit and dust emissions from incinerators which, following the issue of a guideline document in 1977, seemed to have died a death. He asked Mr. Short whether he knew of any particular reason why the Second Working Party's recommendations had never been fulfilled in regulations.

Secondly, he commented that Mr. Short had stuck rigidly in his paper to the incineration of domestic or commercial waste, and had not mentioned any type of special waste. Mr. Dodds said that he had a particular interest in hospital (clinical) wastes and wondered whether Mr. Short had any comments to make about progress towards improvement in that area of incineration. Mr. Dodds believed that many people shared his concern about the difficulty of resolving the problems involved in the incineration of that type of special waste.

Turning to Dr. Farquhar's paper, Mr. Dodds said that while he did not wish to hog the floor, there were many points on which he would take issue with Dr. Farquhar, either then and there or elsewhere. He assumed, in fact, that Dr. Farquhar's paper had been deliberately provocative. Taking at face value Dr. Farquhar's comments that tremendous strides had been made in the chemical industry in dealing with emissions, Mr. Dodds remarked that it was nevertheless very difficult to persuade people in the Bristol area and elsewhere in the country that a brown visible plume of nitric oxide, emitted from a chemical works, was in fact less polluting this year than it had been last year when it was still a brown visible plume. Although he was personally aware that great strides had been made in improving the quality of that type of emission, he said that as far as the public was concerned, the fact that the plume was still visible gave rise to concern. From a PR point of view alone, it might be useful to the industry if it were to decolourise the plume and render the "fume" less obvious. There were other examples of that kind, where similar action would greatly improve the public's perception of the industry.

He had also been interested by Dr. Farquhar's comments on best practicable means. His own experience had taught him that there were circumstances where best practicable means just did not work: where, having used them, a nuisance or a problem still remained.
He recalled an incident in the north east some years back, concerning a company which produced a methacrylate and acrylate. If his memory was correct, the odour

threshold had been in the order of 0.00043 parts per million. All the best practicable means in the world could not prevent one teaspoonful on the north bank of a well known river causing a major nuisance some two miles away on the southern side of the river.
He wondered whether in fact, BPM should go much further than Dr. Farquhar had suggested, and whether his crocodile tears shed in plea for variable standards depending on need had in fact been deliberately controversial, with the intention of stimulating discussion that afternoon.

On indoor air pollution, Mr. Dodds asked Dr. Melia how the householder, concerned about levels of pollution indoors, could achieve a balance between that concern and the need to achieve low energy costs - to save heat, in fact. It seemed that some bpm or bpeo compromise had to be made between indoor air pollutants on the one hand and energy costs on the other. So far, Mr. Dodds considered that people had not got the balance right and he felt that studies such as those described that afternoon were effective in illustrating some of the problems, but did not necessarily offer the answers.

DR. R.J.W. MELIA said that the concern with saving energy and in effect sealing up the home had started in the United States and spread to the UK, and with it had come, perhaps, the increasing risk of raising levels of pollutants indoors. At this stage, she considered that it would be wrong to scaremonger and assert that people would go down with various illnesses because of the trend towards greater insulation. She thought it was necessary to monitor carefully what the result of increased energy saving measures was in terms of air quality indoors.

DR. J.T. FARQUHAR, replying to Mr. Dodds' point about nitric oxide emissions from chemical plants, said that he had been talking about nitrogen oxides emissions in the broader context of acid deposition, and in that respect chemical plant made a relatively minor

contribution to overall nitrogen oxides emissions, compared with, say, power stations. Mr. Dodds' comments, however, had been in relation to the localised concentration of NOx from nitric acid plants.
Dr. Farquhar said that NOx from a nitric acid plant or similar process might well be emitted in far greater concentrations, although in far smaller quantity, than would be the case with power stations. He agreed that there was a possibility of local nuisance still being caused by these emissions. He did not think that fact was inconsistent with the statement he had made on acid deposition.

Replying to Mr. Dodds' comments about best practicable means, Dr. Farquhar said that he believed that Mr. Dodds was agreeing with him right up to the point when he had called Dr. Farquhar's own comments "controversial". In fact, he still thought that broadly he and Mr. Dodds were in agreement. Dr. Farquhar believed that bpm did not always provide the right answer. It might be that using the best practicable means resulted in controls far more stringent than were actually required.
On the other hand, the use of bpm might result in a level of control which was far less adequate than it should be. When best practicable means simply were not good enough, then it created great difficulties.
In such a case, either standards had to be changed, or a plant had to be shut down.

MR. W. SHORT, replying to the point about lack of progress since the Second Working Party on Grit and Dust Emissions had reported, said that he simply did not know the answer. When he met with officials in the DOE, or with the Industrial Air Pollution Inspectorate, everybody blamed someone else for the lack of progress. At one time, there had been the suggestion that regulations had not been forthcoming due to pressure of parliamentary business. Another view was that the difference between the grit and dust standards for conventional boilers and the draft standards for incinerators etc was so great that the issuing of official regulations relating to incinerators might be said to show up the laxity of the boiler standards.

As an aside, he said that it rather intrigued him that NIFES had found itself in the role of unofficial advisor for the Government, and were constantly being asked to give guidance for grit and dust emissions from incinerators. Both local government and central government officials referred people to NIFES for advice on this matter. In vain did Mr. Short tell people that all he was doing was describing what was in a report which had never acquired the status of official regulations.

His view was that regulations setting grit and dust emission limits for incinerators should be issued. It was quite wrong to have to tell people to follow draft guidelines, and advise them that if they did so, they would probably be all right once actual regulations were in being. As NIFES was not a Government department, they could do no more than keep prodding official sources on the matter, and he hoped that other concerned individuals or local authorities would do the same.

On the second point about hospital waste, Mr. Short said that it did present a particular problem. The waste was not of a consistent quality: for example, geriatric wards produced a waste very similar to normal household waste, whereas surgical wards produced what could only be described as very wet material. This was not self-combustible; in other words, it needed additional fuel to dry it before it would burn. When hand-fired Lancashire boilers had been in use in hospitals, there had been no problem with surgical waste: they had simply been fired onto the six foot long grate of incandescent fuel, and had been incinerated with no problem at all. Now however, with the packaged oil and gas fired boilers, that was impossible. Quite apart from that, regulations had been introduced specifying the "proper" handling of human residues.

In his view, it was not possible to burn clinical hospital waste properly in a simple packaged incinerator. The residence time in the after-chamber simply was not long enough. One workable method was to mix the waste in with more general hospital waste of a more combustible nature and, if necessary, use additional fuel to achieve proper combustion. Special small incinerators for hospital waste led, in his view, to problems due to insufficient attention. Some designs used a special "pathological" hearth to expose such material to high temperature gases from combustion of more normal waste.

MR. D. BIRD (NSCA Yorkshire and Humberside Division and Sheffield City Council) first assured Cllr. Mrs. Solkhon that the question of aerial crop spraying would be pursued through the NSCA's Yorkshire and Humberside Division. As Honorary Secretary of the Division, he promised to canvass its members and return the results to the Society's headquarters as soon as possible.

He asked Mr. Short whether he had experience of the problem of mixing domestic waste with sewage in an incineration plant. He sought Mr. Short's opinion on the potential of that process for emission of heavy metals to the environment.

Referring to Dr. Farquhar's comments about people having the choice between greater affluence, and some measure of pollution, or a lower standard of living and greater environmental cleanliness, Mr. Bird said that he came from an area where people ate sausages and put up with strong and unpleasant smells from industry. However, he did not wish to rise too much to Dr. Farquhar's bait, but simply wanted to point out that industry did not always reflect the wider aspiration amongst the population for an improved environment, or the more general public concern about our international responsibilities. However, he asked Dr. Farquhar to recognise that many people believed that it was not up to the agencies who controlled pollution, or members of the public, to prove that pollution from industry was doing them harm. The polluter should prove that the need for controls did not exist rather than the other way round.

Turning finally to Dr. Melia's presentation, David Bird said that he understood both from that presentation and from previous communciations between Dr. Melia and Sheffield City Council's Environmental Health Department, that much of her findings had been based on questionnaire data. One of the questions that had been raised in Sheffield was how much reliance should be given to data collected by non-clinical, untrained personnel, particularly if the mothers were in the so-called lower social classes, and might not (according to some views - which Mr. Bird did not personally subscribe to) be able to make objective judgements about the health of their children. He wondered how much such factors had been taken into account in assessing the variance in the results.

DR. MELIA, replying, said that the point had been considered in various of their studies investigating respiratory illness in children. In the first study relating to nitrogen oxide emissions, an objective study of the children's health had been carried out, i.e. observation of lung function. That had been used alongside questionnaire data in several of their studies, including the first, the national investigation of air pollution. Repeatedly, the studies had shown that where a mother reported a health problem, the lung function study showed either lower lung function or a specific impairment.

There was obviously some tie up between the questionnaire data and the objective lung function data, but this provoked many arguments as to what exactly the two different methods were measuring, since they did not tie up completely. Some people tended to believe more in the questionnaire data than in the lung function data; Dr. Melia personally believed that the truth lay in a compromise between the two.

As to whether or not the questionnaire data was in some way biased, Dr. Melia commented that the mothers had been unaware that the interest of the researchers who used the questionnaire was in whether cooking was by gas or electricity. All they had been told was that the study related to general aspects of the environment in Middlesbrough. That was unlikely to have biased the results. Another option would have been to have obtained the answers by using an interviewer. However, that had been shown by special studies of interviewer technique, using tape recorders, to introduce all sorts of special interviewer biases. Interviewers could sometimes frame their questions in such a way as to obtain certain answers from people. A large study, using several interviewers, would run into even more problems.

In summary, Dr. Melia believed that their study truly revealed a degree of respiratory impairment. This was confirmed by other studies of hospital and General Practice data, and this method of recording respiratory illness had been used in a number of studies, by a number of research groups.

DR. FARQUHAR said that he would not fundamentally disagree with David Bird's comments, except with the remark that it was up to industry to prove that it did not endanger anyone or anything. Dr. Farquhar remarked that it was increasingly difficult to prove anything in the environmental area. Really, it was necessary to consider the balance of interests, and the likelihood (sometimes the high likelihood) that something was the case. In fact, industry was very active in feeding data into the national and international system. He hoped that he had not, in his talk, given the impression that industry wished to opt out of the decision-making process.

MR. SHORT said that originally, the Altrincham incinerator had burnt some sewage sludge, with the sludge being atomised over the burning refuse on the grate. These trials had proved that quite an amount of sewage sludge could successfully be incinerated into harmless products with domestic waste. However, since local government reorganisation in 1974, sewage sludge had not been burnt on that incinerator because the Water Authority and the Greater Manchester Council had become separate authorities and no longer combined to cover the costs and responsibility which appeared fair to both sides. Thus, a plant which had shown itself capable of burning a certain amount of sewage sludge was no longer doing so.

In Switzerland he had seen plants in which sewage sludge was treated by coagulants through a continuous filter press system to give a relatively good filter cake, which was then mixed in with the ordinary refuse, just in the entrance to the incinerator (not in the main bunker, because it would ferment). Again this incineration method worked satisfactorily. There was no particular problem with burning sewage sludge together with domestic refuse, except that if it was sprayed in just as it came from the sewage works, only a relatively small amount could be burnt because of the vast amount of water to be evaporated, which stole heat from the combustion chamber. A filter press increased the percentage of solids from 3 to 4%, to around 20%, which meant that a great deal of the sludge could be burnt successfully. It was almost self-combustible at 20% solids content. Multiple hearth incinerators with rotating rake arms to progress the filter cake from one hearth to the next had proved to be satisfactory.

CLLR. R. KIDD (Newtownabbey B.C.) asked Dr. Melia whether her sampling had been carried out indoors at ground level or at ceiling height. The Building Regulations specified a particular ceiling height, which was intended to prevent the build-up of pollutants at breathing level. Most architects specified air changes in a room on the basis of the burning of an ordinary room heater, at about 50 square inches per unit, which gave allowance for air intake through faulty windows and doors. Problems would only arise with a well built house. He asked Dr. Melia whether the air intake had been specifically measured.

Turning to Dr. Farquhar's paper, Mr. Kidd commented on the choice put forward in Dr. Farquhar's address, between eating roast beef on Sunday and living beside a river that was incapable of supporting fish life, or eating bangers and mash beside a clean river, and said that that argument personified the clash between profit-making and the press for environmental improvement. In his view it would be preferable to eat sausages made of soya beans and have clean water; in addition, he observed that if the water was clean, one could eat the fish living in it - they would be as good as roast beef. He asked Dr. Farquhar whether profit was ever a restraining influence on industry, forcing them to co-operate with local authorities and other authorities responsible for protecting the environment.

DR. MELIA said that they had tried to control for sampling height in all homes. The aim had been to sample at a height of about five feet, which was not exactly within a child's breathing zone, but prevented any tampering with the measuring apparatus by young children. In the kitchen, they had also monitored at two sites within a fixed distance of the cooker. Thus, they had aimed to standardise sampling in all homes.

Dr. Melia said that air intake had not been measured. It was a very interesting component and no doubt the variation in air intake contributed to some of the variation in levels of nitrogen dioxide found in different homes heated by gas, or using gas for cooking.

DR. FARQUHAR said that while he felt that the first two speakers had basically been in agreement with him, that was not the case with Mr. Kidd. He made no apology for being a supporter of the profit motive and considered that industry was in business to make a profit.

MR. K. TEESDALE (Ford Motor Co. Ltd.) asked Dr. Melia to expand on her table (showing the various pollutants that might be considered in the indoor situation), with particular reference to the internal atmosphere of motor vehicles. To an increasing extent, the motor vehicle was becoming a "mini-home". The increased sophistication of heating and ventilating inside vehicles was perhaps creating a situation similar to that which had developed in people's homes. In order to increase efficiency and reduce noise, windows were becoming more tightly sealed and heating systems were more sophisticated. This accidental or designed reduction in ventilation increased the likelihood of raising the occupants' exposure to substances which had been largely unconsidered in the past: solvents, formaldehyde, phenols, etc. Another factor was humidity, which might induce the same type of "humidifier fever" associated with buildings.

DR. MELIA said that Mr. Teesdale had summarised the position very well. She would simply elaborate by giving a few details of research in the area. The origin of the concern had been in the United States, where they had perhaps begun to seal up their buildings earlier than in the UK, and had used various types of artificial material, eventually giving rise to the problem which was of concern both there and in Scandinavia, the so-called "sick building syndrome". This did not necessarily occur in homes, but in offices, where there was artificial ventilation, and where various new substances were being used for carpeting, wall coverings etc. People had complained of symptoms such as headaches, sickness and so on. So far, despite considerable research in the USA and in Scandinavia, no-one had been able to pinpoint the cause of the problem exactly. Dr. Melia said that she was unaware that any general "sick building syndrome" had been reported as yet in the UK.

Humidity was another important and interesting problem. In their last nitrogen dioxide study, her group had also measured relative humidity and had found a positive association between increasing relative humidity in children's bedrooms and the prevalence of respiratory illness in children. The increased sealing of buildings could possibly lead to an increase in mould growth and to the presence of allergens, which could lead to allergic-type symptoms or possibly to increased droplet infection. The whole area needed further investigation.

Another aspect that had been studied both in the US and the UK was that, with artificial ventilation, infections could spread quite rapidly. This had been demonstrated in some hospitals, and had even been shown to be the cause of contamination in some operating theatres.

SESSION FOUR

AIR POLLUTION TRENDS AND EFFECTS

TRENDS IN ACIDIFICATION OF PRECIPITATION IN THE UK AND WESTERN EUROPE

C.F. Barrett, Warren Spring Laboratory

OZONE FORMATION AND NATIONAL TRENDS

Dr. R.A. Cox, Harwell Laboratory

EFFECTS OF AIR POLLUTION ON CROPS AND TREES

Dr. T.M. Roberts, Technology, Planning and Research Division, Central Electricity Generating Board

DR. M.J.R. SCHWAR (GLC, Scientific Services Branch), opening the discussion, said that the three papers presented had been most useful in helping to unravel a complex environmental pollution subject involving emissions, chemical processes taking place in the atmosphere, and the resulting damage.

The question of trends was important, fundamental to the understanding of the problem itself, and to the understanding of how the three factors - emissions, chemistry, and deposition - and then the eventual damage, all interacted. It was essential that those processes were well understood in order to optimise the pollution control strategies which might be developed.

Quite another question was whether sufficient time remained to resolve fully all the questions involved. The discussion the previous day had seemed to indicate that the public perception of the problems was such that some decisions had to be taken now, in order to respond to public concern. Baroness White had made the point that both industry and local authorities (the latter being very much in the forefront of responding to public concern) had to be seen to be concerned about the problem of environmental pollution, and not to go to the other extreme by attempting to play down the problem. Public concern had to be seen to be recognised, and the public had to be provided with as much information as possible about the state of the art. It still was very much a state of the art - all the problems had not yet been identified - but it sometimes appeared to the public that industry and the authorities were holding back information. Dr. Schwar considered that there ought to be a greater exchange between industry, local authorities and various interest groups to make more widely available whatever information there was.

Turning to the consideration of trends, he said that there was an obvious lack of data against which trends could be assessed. There was a lack of data on air pollution levels, including ground-level concentrations, and there was a lack of data on the effects of pollutants on the various systems which were the subject of current concern. While each of the authors had attempted, most carefully, to summarise the current position, there were clearly still gaps in knowledge. The problems of retrospective analysis of pollutant levels were clearly formidable, and there were also question marks over the extent to which air pollution was causing the damage observed, when there were other confounding influences at work. Another factor yet to be resolved was the relative contribution of background levels of pollution, as against the more localised and immediate emissions from the various sources that had been identified as possible causes for concern - both stationary and mobile sources. Finally, there was also the difficult question of linearity.

In view of all the difficulties in retrospective examination of the data already available on pollutant levels, Dr. Schwar asked the authors what they would wish to see achieved by future monitoring programmes. He asked what they considered as essential to enable people, 20 years hence, to look back and congratulate present workers on having had the foresight to initiate a useful monitoring programme: something that would be relevant to problems (possibly as yet undetected) that might be of concern in 20 years' time.

Secondly, Dr. Schwar asked for the speakers' comments on the relevance of monitoring today in developing a pollution control strategy. In his view, there was clearly a need to link emissions to damage. Some attempt had been made, particularly in Dr. Roberts' paper, to summarise how this could be done. However, Dr. Schwar wondered whether modelling had been developed to the point where it could be used in the process of developing effective pollution control strategies, particularly bearing in mind the whole range of interactions involved. He wondered whether today's decisions were going to have to be based on very crude approximations and on very simplistic calculations.

In his view, it was time to carry out a more systematic collection of data from both stationary and mobile sources. To some extent, this had been done in the past four or five years. Within the Greater London area emission inventories had been set up, with industry, commerce, and the Borough authorities all co-operating in collecting this information. However, on a nation-wide basis (and it was national and international problems that were under discussion) there was scope for a more systematic collection of data. This could usefully be carried out by local authorities, which had the closest liaisons with local industry, but there had to be a greater and freer exchange of information between the authorities and industry, and both sides had to shed their reluctance to give information to the public. In that connection, the need for confidentiality was often cited, but Dr. Schwar wondered whether the kind of information involved really required confidential treatment, particularly if the information was provided to an appropriate body, appointed to acquire the information, and that body acted in a responsible way. In such circumstances, he could see no reason for questions of confidentiality being raised.

He therefore asked the speakers whether they saw scope in the future for the development and application of models which were beginning to be produced, to throw greater and more effective light on the relationship between emissions and effects.

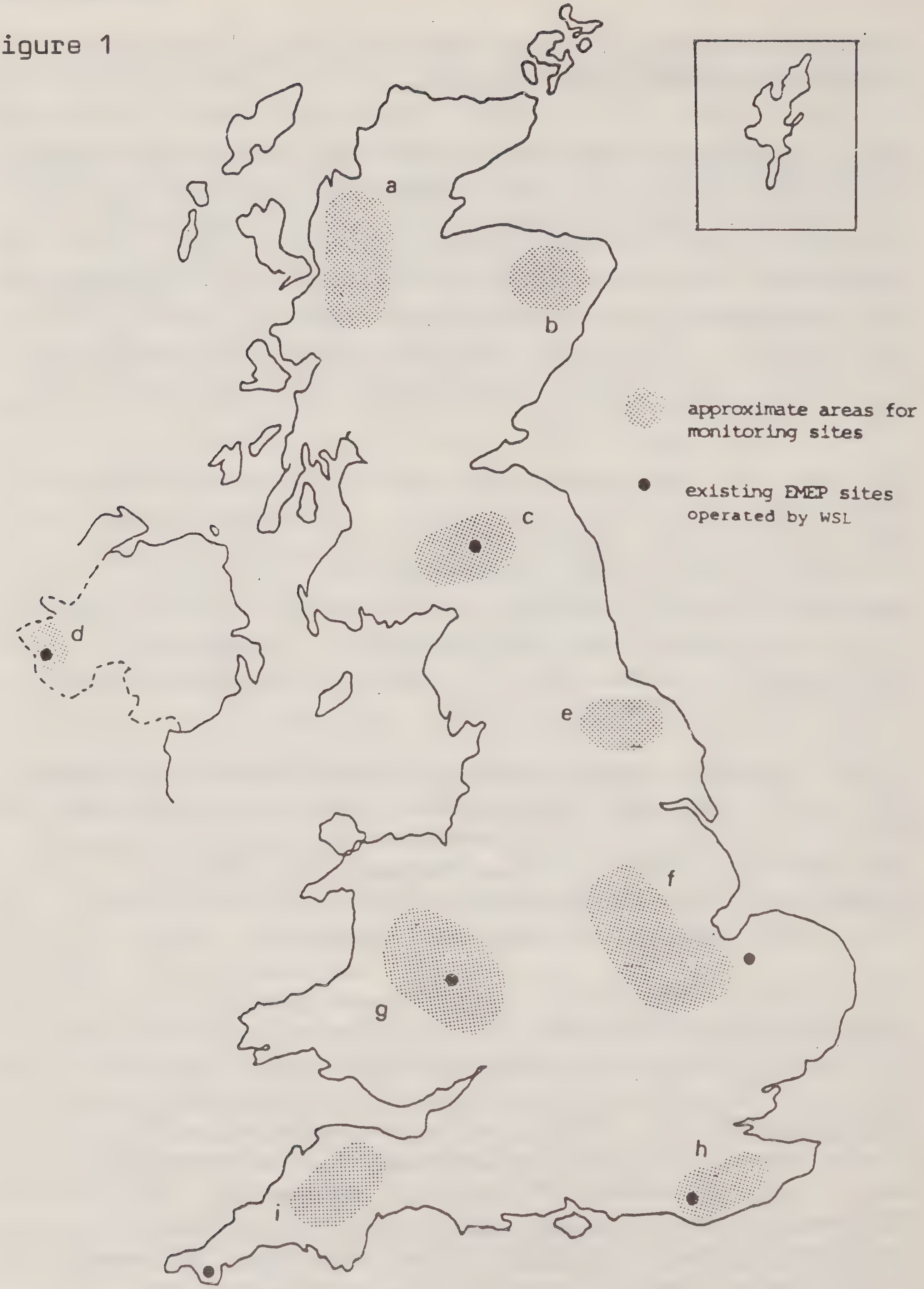
MR. C.F. BARRETT, replying, said that one of the figures he had been unable to show because of lack of time had been an overhead relating to the future monitoring exercises which the Review Group on Acid Rain had identified (at the request of DOE) as being necessary. The recommendation had been that monitoring should take place in nine areas selected to be representative of the various concentration/deposition regions in the UK, as shown in Fig. 1.

The idea was that monitoring should be carried out in these areas on a long term basis. An attempt would be made to minimise contamination by ensuring that the collectors were closed in dry weather, and daily measurements would be done so that they could be tied in with meteorological trajectories. Overall, it would provide a data base for the future, which would avoid the problems of the past.

He had gleaned various remarks during the coffee break which indicated that people felt that scientists had been very careless in the past to have acquired such poor data for present use. However, Mr. Barrett pointed out that there were many difficulties to be faced when setting up long term networks.

For a start, long term monitoring was unpopular with many administrators, and with some organisations. Such people tended to lose interest in the project, and say, "This has been going on for years and years. Can't you stop it, and go on to something else?" It was hard to get people interested in monitoring, and it was even more difficult to know what information people would want in 20 years' time. For example, people might by then have lost interest in acid rain, and be focusing their attention on something else. There were genuine problems with long term monitoring, and the inadequacies were not just due to carelessness; the problems that the

Figure 1


a
b
▨ approximate areas for monitoring sites
● existing EMEP sites operated by WSL
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Proposed network for long-term monitoring of acid deposition

Meteorological Office had with their site had not been due to scientific incompetence (Mr. Barrett did not think that they were incompetent, in fact they were highly competent people). The problems were due to the fact that the importance of data in relation to trends in acid deposition had not then been recognised, as well as all the other factors associated with long term monitoring.

DR. R.A. COX agreed that one of the problems with monitoring was that one was always wise after the event. If, ten years ago, people had known what they knew in 1984 about acid deposition, they would have known exactly what to monitor then. Nevertheless, that did not mean that people should be complacent. After all, monitoring the components of rain had begun in the 1860s at Rothampstead, and the importance of the chemistry of rain for agriculture had been recognised for some time.

Turning specifically to the problems associated with ozone, Dr. Cox said that it was both a secondary pollutant and a natural constituent of the atmosphere. Thus, to derive information about the pollution component required adequate information on the background of ozone at the particular site or area of interest.

Turning to another point raised by Dr. Schwar, the linking of emissions with dose and effects, Dr. Cox agreed that modelling was the correct tool for the future. Models should be used in the decision-making process on action and policies concerning relationships between primary pollutants and secondary pollutants, etc. Dr. Cox expressed a measure of hope regarding models of ozone formation. In the past ten or fifteen years, research work had established with a great deal of certainty the chemical basis for ozone formation and its link with the atmospheric reactions of nitrogen oxides and hydrocarbons (the primary pollutants). The problem lay in the fact that these relationships were extremely complex and in order to derive a model some simplification had to be made to the chemistry. It was essential to ensure that, in making these simplifications, artefacts or errors were not introduced in the final result. The other factor was that there was a great deal of meteorological input into such models, if the attempt was being made to predict an effect at a particular place and time. All in all, he considered the situation to be hopeful as far as models were concerned, and felt that some improvements would soon be seen. He recommended continual effort and some increase in activity in that area.

DR. T.M. ROBERTS said that the inadequacy of UK data was due to a national trait. The UK had to turn to the Scandinavians for good data on rain chemistry, and to the Germans for results from a solid network of stations that had been measuring SO_2, NOx, ozone and rainfall chemistry for some ten years. Admittedly, until the previous year or so, all the data had been locked up in rather large rooms, until its importance had been realised. Nevertheless, they had had the data, while, historically, Britain's data base was less adequate.

Turning to the subject of modelling, Dr. Roberts said that without doubt biologists were lagging behind. Physicists had got to the stage where, at least on the basis of some reasonable assumptions about linearity, they could come up with some distribution maps showing dry and wet deposition for the UK. In response to the charge that these were only correct within ± 50%, the physicists responded by saying, first, that that was better than nothing, and secondly, that if the monitoring data did not fit the model, then they would simply change the model until eventually they got it right!

On the whole, he considered that the physicists were well ahead of the biologists - with one notable exception - the National Crop Loss Assessment

Network in the US. That programme, at five sites and on a range of crops, had been set up with a view to the data being used in economic models of crop losses. That was a step forward. The reason that something similar had not been done before was that in order to overcome the great variability involved, large scale experiments had to be set up, which was very expensive. Until recently, biologists had been the poor relation as far as funding for air pollution research has been concerned. That had now changed, and the National Crop Loss Assessment Network did, in his opinion, point the way ahead. He considered that something similar should be established in the UK.

CLLR. J. ROONEY (Newtownabbey BC) said that it had been estimated that to achieve a 30% reduction in SO_2 emissions from power stations in the UK would entail £1 billion capital expenditure and £250 million per annum in running costs. That would correspond to an increase of some 4-5% in the price of electricity. In view of those costs, he asked for the panel's comments on an alternative means of control: the use of an additive of extremely fine alkaline powders, such as magnesium hydroxide, which could be introduced into the flue gases via the ducting, just before entry into the chimney. The quantity added would be less than 0.1% of the fuel consumed, and the additive would be carried in the flue gases, to be precipitated only when the rain area had been reached. The fine powder would help to neutralise both oxides of sulphur and oxides of nitrogen, and the costs would be approximately 1% of those associated with conventional flue gas desulphurisation.

MR. BARRETT, in response, said that the method described was in itself a technique for flue gas desulphurisation. The difficulty was that, to be successful, it would require a great deal more engineering than had been described. The addition of magnesium oxide had been considered amongst the range of options for flue gas desulphurisation.

Properly engineered, it would be one of the systems considered in arriving at an overall cost for FGD. As described, he did not consider that the process could work; it was essential to ensure that the magnesium oxide contacted the gases.

DR. COX, who said that he was a chemist rather than a physicist, nevertheless felt that it would be difficult to achieve flue gas desulphurisation using the method described. He thought it unlikely that the powder would be carried as far as the gases, but rather, that the powder would fall out rather close to the source of emissions. That would create even greater air pollution problems.

DR. ROBERTS said that the matter was outside his area of expertise, but he had picked up some views from the CEGB engineers as to what the options for reducing sulphur emissions were. He believed that this idea had been put to the engineers, who had ruled it out on the grounds that it presented too many practical difficulties. Putting calcium or magnesium oxide in as a liquid (as a spray) was one of the recognised methods of flue gas desulphurisation. However, since the CEGB was coming under increasing pressure to control particulate emissions ever more tightly, (which had recently led them to update their use of electrostatic precipitators) the idea of adding more particulates to stack emissions was unlikely to be acceptable.

Coal washing was the cheapest method of removing small amounts of sulphur from the fuel, rather than from the flue, but there was a definite limit on the amount of sulphur that could be removed by that method. At present, FGD on the large power stations was the most favoured method of achieving any stringent requirements for emission control that might be made in the future.

Taking the British "Aim of Policy" to achieve a reduction of 30% (on the 1980 base) in emissions by the year 2000, Dr. Roberts said that 17-18% reductions on 1980 emissions had already been achieved, which left another 12% or so to be secured in the next 16 years. Whether or not FGD would be fitted would depend largely on the rate at which the CEGB's nuclear programme developed. At present, that programme was hung up at the Sizewell Inquiry.

Were a 60% reduction in SO_2 emissions to be required, obviously FGD would come in to play, with the sorts of costs mentioned by Cllr. Rooney.

THE CHAIRMAN, Dr. R.A. Barnes, summarising the response of the speakers, told Cllr. Rooney that the method might work at a plant, but the additive was unlikely to carry to the receptor areas and it might therefore be simpler to add alkali within the catchment area rather than hoping to make it travel with the acidic plumes.

DR. K. GRAFE (private individual, domiciled in Hamburg, FRG) said that the three papers had given him great pleasure, particularly since, during the course of more than twenty years he had made many measurements of air pollution in Hamburg.

Turning specifically to Mr. Barrett's presentation, and to his last slide in particular, Dr. Grafe said that he would not have dared to show such a slide with isopleths over the whole of Europe. Casting his mind back to the 1960s, when he had met with Dr. Craxford and Mrs. Weatherley of Warren Spring Laboratory to discuss the WSL results and the measurements done in Hamburg, he recalled that they had preferred not to derive such isopleths for Europe as a whole, in spite of what the politicians would have wished. Such isopleths were really a very crude approximation of the real situation. He recalled a paper presented by one of Mr. Barrett's WSL colleagues, on measurements of air pollution at Heathrow, which had shown that in spite of air pollution caused by aircraft at Heathrow, the air quality there was better than in many suburbs of London. Such variations did not show up in the isopleth diagrams.

Turning to Dr. Cox's presentation, he said that Dr. Cox would know, as he did, that the maximum level of ozone was not always to be found at 25 kilometers - that was the average height of maximum concentration. It was important to realise that this was only an average when considering the hypothesis put forward by some people, that the ozone layer might be destroyed by air pollution.

He had been particularly interested in Dr. Cox's figure showing a maximum level of ozone in spring, and a minimum in the autumn. His own measurements of total radiation (from the sun plus sky) had also shown a maximum in the spring and he recalled that at an Oxford Conference some years back, there had been a similar trend in ozone and radiation. In spite of these results, studies of the effects on human skin had shown a stronger erethemal effect in the spring than in winter, which might be only partly due to the fact that people's skins were not accustomed to ultraviolet radiation after the winter.

Dr. Grafe offered Dr. Roberts his particular congratulations for what he termed an objective paper. He thought that the "Greens" in Germany could benefit from the paper. People in Germany tended to forget that it was not only air pollution which damaged trees; as Dr. Roberts had noted on page 16, trees could also be affected by drastic changes in temperature. Biologists in Hamburg always made the same point but were outweighed by the many other people who concentrated solely on air pollution instead of considering all the other facts.

MR. BARRETT, replying, said that the last slide he had shown had been a model drawn up by a research worker in the Central Electricity Research Laboratories. The isopleths had shown general regional averages, within which one would obviously expect to have variations due to local sources. The effects on sulphur deposition scavenged from rain due to the impact of emissions from local sources would not be as great as the effect on concentrations in the air. He was not sure whether perhaps he had misunderstood what Dr. Grafe had said, but if he was correct in assuming that Dr. Grafe thought that such things should be concealed from politicians, Mr. Barrett said that he disagreed. He believed that scientists should be as objective as possible, and should present the facts fairly and completely.

DR COX said that the figure he had shown of seasonal ozone had, in fact, been of the seasonal variation at ground level. That had no significant effect on atmospheric radiation. As Dr. Grafe had correctly pointed out, ozone at high altitude did have an effect on radiation. In fact, the ozone at high altitude, at the UK's latitude, showed a similar seasonal variation to the ground level ozone, with, indeed, a somewhat higher amplitude. The intensity of the ultra violet radiation (and it was the ultra violet radiation which produced the erethemal effect) would be strongly filtered in the spring time (in April and May) and would show a larger component later on in the summer. Although not an expert on atmospheric radiation, Dr. Cox said that as far as he knew, that trend did fit in with observations.

DR. ROBERTS wished to make just one point in the German forest decline. He said that until 1970 there had been a very good West German group studying the effects of air pollution on forests, at the Landesanstalt in Essen (LIS). However, between 1970 and 1980 virtually no work had been done on air pollution effects. Thus, when symptoms had begun to show themselves in the trees in the German forest, there was a vacuum of knowledge on air pollution effects in Germany, and it would take them several years before they could get the expertise back up to a level where it would be possible to make authoritative statements. The only fumigation studies of any standing were the ones at LIS (Essen) which had remained unused for almost ten years. With the recent upsurge of interest in the subject, he believed that research studies would start to move ahead again, but the present position was that there were almost as many hypotheses as to what was causing the forest damage, as there were scientists studying the problem in West Germany. It would take a year or two to get the facilities in place to test the various hypotheses. That was the state of the science in West Germany, but in the meantime emission controls were going ahead apace. He could only hope that the politicians had got it right.

CLLR. H. LANCASTER (Middlesbrough B.C.) said that he had always believed that, while a great deal of research had been carried out on SO_2, far too little had been done on nitrogen oxides. Living near Middlesbrough, he had travelled each day through the little village of Billingham which was the home of the largest chemical complex in Europe. Each day he saw the reddish-brown fume of nitrogen oxides pouring from the two "tin cans". In the early days, very little had been done about oxides of nitrogen, and attention had only recently focused on those emissions. Cllr. Lancaster had been disturbed by receiving information from one of his former students, now doing post-Doctorate research into oxides of nitrogen in the US.

Briefly explaining the chemistry, he said that as many people would know, oxides of nitrogen were soluble in water, producing a mixture of nitrous and nitric acid, which would ionise and produce a nitronium ion - which was an extremely active ion. Taken together with the enormous quantity of unsaturated hydrocarbons produced from ill-adjusted and badly maintained internal combustion engines, this produced a pretty desperate mixture, resulting in the production of carcinogenic organo nitro compounds. He asked the speakers whether any research was being conducted in that area, and if so, what steps were planned to reduce the emissions which gave rise to these carcinogenic substances.

DR. COX said that the Royal Society had held a meeting entitled "Pathways of Pollutants in the Atmosphere". One of the most memorable lectures at that symposium had been by Professor James Pitts, from Riverside, California, who had had as his theme just the area that Cllr. Lancaster had referred to. Professor Pitts had given a very erudite description of the reactions involving nitrogen oxides and organic species, producing in the atmosphere carginogenic materials such as nitramines and nitrosamines. Since that time, a great deal of work had been done in that area in California, to see how significant the formation of these substances in the atmosphere was in terms of human health. The conclusion to date appeared to be that it could not be dismissed, but was not one of the major, important effects of nitrogen oxides in the atmosphere. Compared with the problems discussed that morning - the ozone problem, and the coupling of nitrogen oxides and the hydrocarbon system with the acid deposition problem, the interactions that Cllr. Lancaster had referred to were considered to be far less urgent at this time. However, Dr. Cox considered that it was something that still needed to be watched, and was of particular interest in relation to the presentation the previous day by Dr. Melia. When Dr. Cox had recently visited California, he had learnt from Professor Pitts that his interest had turned to the possibility of these reactions occurring in the atmosphere indoors.

CLLR. R. COOPER (Walsall MBC) said that his home town had a variety of air pollution problems. Listening to the speakers both that day and the previous day, he had concluded that the resolution of any air pollution problem boiled down to being able to extract sufficient money for the purpose from central government. He thought that rather than reflecting on levels of pollution in the past or even at present, the attention of the Conference, of government and of the EEC should turn towards the future. The aim should be to look ahead to, say, 1990 and seek measures which would achieve a gradual reduction in levels of pollution that were of real concern from the point of view of human health.

Another difficulty that he perceived from the viewpoint of a West Midlands town with many non-ferrous works, was that it took an inordinate amount of time to extract results from the authorities (among them Harwell) who were responsible for conducting the monitoring at various sites around the town. It could take six or nine months for the data to be fed through to the local authority. In terms of the responsibilities of the local authority, it was useless to have a piece of paper that said that nine months previously there had been what amounted to an illegal emission from a particular company. After such a lapse of time, the local authority could do nothing about the emission. Indeed, the firm might very well have gone out of business in the intervening period!

Referring to another of the problems encountered in Walsall, Cllr. Cooper said that they were at present conducting blood lead tests on a number of children in the area. That type of exercise made him even more aware of the need to control air pollution more carefully in the future, so that we could avoid the mistakes of the past.

MR. BARRETT said that, were results required very quickly, WSL could produce them very quickly.
In general, data was produced and supplied to the local authorities at intervals which were the shortest that were practicable.

Turning to the latter part of Cllr. Cooper's remarks, he said that it was very difficult to project trends forward, although it was certainly desirable to do so. The chief difficulty lay in the fact that it was impossible to know exactly what the emissions would be, since they depended on the level of industrial activity. However, there was some activity along those lines, and there ought in his opinion to be more.

DR. COX said that projection into the future had to rely on a model of some kind. It could be either a simple model, or an attempt at a complete description of the phenomenon which it was considered desirable to predict. Whichever type was chosen, it was essential to have some degree of faith in the model. If the scientist had no faith in the model, there was no point in trying to do such predictions. Some scientists actually had faith in their models, but were nevertheless criticised for making predictions on that basis. Thus, they were very reticent about predicting the future.

Turning to the frustrations which Cllr. Cooper had experienced with the administrative procedure at Harwell, Dr. Cox said that he really could not comment, except to say that as a working scientist in that establishment he experienced just as much frustration with the paperwork and procedures, as Cllr. Cooper obviously had as an outside contractor who wished to get a quick answer to a technical question.

DR. ROBERTS said that 1990 was only five or six years off, and by then it would probably be possible to assess exactly what the great experiment in sulphur oxides control had achieved. It had to be remembered that in the UK sulphur dioxide emissions had decreased by 37% since the early 1970s. The UK was the only country in Europe which had brought its SO_2 emissions (albeit involuntarily) down to their pre-1950 level. The consequence of that reduction on the British environment had yet to be fully evaluated. Some data had just come out in Scotland on changes in rainfall acidity. It was a matter for speculation as to whether there would also be changes in stream chemistry and fishery status of streams, what the changes in agriculture would be (it was known that there was now increasing use of sulphur fertilisers in Scotland). By 1990, the consequences of the large change in emissions that had taken place over the past decade would have been analysed and we would then be in a position better to assess what further changes in control might be required beyond 1990.

MR. A. VERDIN (Analysis Automation) said that the whole discussion had revealed the great need there was for further monitoring. Making it clear that he spoke as a manufacturer, Mr. Verdin said he would have liked to have been able to speak on behalf of the whole British monitoring manufacturing industry, but regretted the fact that, apart from his own company, it did not exist in the area under discussion. The instruments were not made in Britain, because monitoring was not carried out in Britain; therefore, his own company imported instruments as requisite. He hoped that the Conference would give a lead of some kind. He disagreed with Dr. Cox's remark that it was always easier to look back and see what one should have been monitoring, years after the event. In fact, Mr. Verdin felt that for the past ten years at NSCA and other conferences he had been trying to point the way ahead. He now predicted that the UK would shortly fall in line behind Germany and require the monitoring of specific emission limits for large industrial plant. Accepting that the prediction was credible, he felt that we might get a bit ahead of the game by turning attention now to the monitoring requirements.

Inevitably, in the short term people in the UK would have to use imported German instruments. However, in the longer term it would become uneconomic to apply stringent emission limits to older plant and in time those plants would be replaced with more modern plant capable of meeting new emission limits, and ideally UK monitoring equipment should be used to measure compliance with standards of emission. If companies in the UK concentrated on such developments, the UK would be in the position to export such instruments rather than having to import them.

At present, all the instruments for measuring ozone were imported and Analysis Automation had supplied a good deal of these, perhaps most of those which had been used in the studies described. Those instruments were imported by his company because other countries did a great deal more monitoring for ozone. In case it should be thought that such monitoring was not carried out in the UK because of the costs involved, Mr. Verdin said that he had recently taken an order from a very much less developed country for 30 hydrocarbon analysers, and expected to take another order from a country with a very small population for another 15 such analysers. Those hydrocarbon analysers, made in the UK, would all be accompanied by ozone monitors made abroad. If such countries could afford to carry out those monitoring programmes, surely the UK could.

He asked the speakers what could be done to stimulate the gathering of data in the UK and at the same time to assist the beleaguered British monitoring instrument manufacturing industry, which generally had to test out their instruments overseas since no-one in the UK was interested in trying them out.

DR. COX said that he thought his talk had indicated the importance which he attached to ozone monitoring. The real theme of his talk had been that nothing could be said about trends in ozone in the UK, simply because the monitoring had not been carried out. The message which he wished to convey was that ozone was an atmospheric property, just like temperature, humidity and pressure, and should be measured as such. The problem seemed to be that no-one had yet sorted out which organisation in the UK would be responsible for carrying out such monitoring. Once that had been resolved, the situation regarding demand for instruments etc. would be more clear cut.

MR. BARRETT said that, as Dr. Cox had implied, the future form of ozone monitoring in the UK was under active discussion. He expected that there would be a great deal more monitoring for ozone in the future.

DR. ROBERTS said that as a biologist, the most difficult part of his work in understanding the effects of air pollution upon crops and plants lay in keeping the instruments going! More reliable and cheaper instruments might be the answer.

DR. S. CROMWELL (DHSS) said that on the map Dr. Cox had shown of regional distribution of ozone monitoring in the south east, the London result had puzzled her. It had begun at near zero and only risen to what Dr. Cox had called his "average level", as illustrated at Littlehampton. In contrast, ozone concentrations in the surrounding areas had been much higher.
Dr. Cromwell asked what the causative factor had been.

DR. COX said that the question was very perceptive. The answer lay in the chemistry, outlined on the viewgraph which, he regretted, was probably not as clear as it might have been. Essentially, the initial effect of nitrogen oxides was to reduce ozone. Near to the sources of emission, the concentrations of nitric oxide were high, which tended to reduce the ozone concentrations. Away from the source region, nitric oxide was oxidised to nitrogen dioxide, and as the ratio of nitrogen dioxide to nitric oxide rose, the ozone concentration increased. In summary, the answer lay in the effect of fresh nitrogen oxides emissions on the ozone levels. The crux of the photochemical ozone system was that it took time to build up the high concentrations of ozone: time of the order of hours was required.

SESSION FIVE

NOISE

NOISE CONTROL OBJECTIVES IN TODAY'S SOCIETY

H. Dawson, Rolls Royce Limited, Bristol

INDOOR NOISE CONTROL TECHNIQUES

J. Simson and S. Turner, Scientific Services Branch, Greater London Council

LEGISLATIVE AND POLICY EFFECTS ON MOTOR VEHICLE DESIGN FOR NOISE AND EXHAUST EMISSION CONTROL

E.J. Cutting and D. Gould, Research and Engineering Centre, Ford Motor Company Limited

MR. W.J. HERON (Brighton B.C.), opening the discussion, said that he welcomed the Society's greater involvement in noise matters. He considered that the Society would fill an important and rather large gap in the market for knowledge about noise control and associated environmental improvement. One of the benefits of NSCA Conferences was the wide range of interests amongst the various speakers. Thus, the Conference could at one point be discussing global issues such as acid rain and the international measures necessary to deal with it, and then turn to noise. Mr. Dawson had in fact mentioned the international links that would be necessary to harmonize noise control, to ensure that we have sensible measures and equitable enforcement.

Basically, however, Mr. Heron's own interest in noise control was more local. Mr. Dawson had quoted the national figures which show a rising trend in complaints about noise. In Brighton, complaints about noise rose by approximately 10% each year. The previous year the Environmental Health Department had received approaching 750 complaints, all on local issues or sources. All required resolution through action by local people, using technology that should have been available to them locally. In dealing with these complaints, Mr. Heron said that he had encountered considerable lack of knowledge amongst those whose real responsibility it was to apply technology to ensure noise control.

Brighton's Environmental Health Department had a very good relationship with the Planning Department, and the EH Department scrutinised all plans in order to make recommendations for measures which would secure a reduction in noise from new developments, and also from conversions. However, the Department had found that if it framed its conditions in the consents in very technical terms, referring to noise indices etc, it puzzled developers, who also did not know where to turn for help and information. Mr. Heron considered that one of the Society's objectives should be to promote increased knowledge on methods and techniques for noise control among those in industry and commerce who had that responsibility at a local level. Those who could benefit from such advice were heating and ventilating engineers, surveyors, architects, the manufacturers of fans, and manufacturers of other noisy equipment in everyday use.

Having done his job for some ten years, Mr. Heron said that he found that where pieces of equipment such as fans had to meet noise level requirements, the specifications were framed in different ways, e.g. some were specified in sound power level, others in sound pressure level. This was very confusing for those with no acoustic knowledge, who could not differentiate between the two. It meant that the Environmental Health Department had to spend some time educating people about the meaning of the various specifications.

In view of the inadequate knowledge locally, he asked Mr. Dawson whether one of the topics that might merit the attention of the Society would be investigation of the ways and means of passing knowledge on to people in the various relevant sectors, e.g. builders, architects and heating and ventilating engineers.

MR. H. DAWSON agreed that it was very important to educate people such as builders and engineers. He himself had been an acoustician for many years and even today much of his work load concerned putting right problems that his company had bought along with equipment etc. purchased. The ridiculous part of the situation was that the equipment he attempted to silence had frequently been purchased by engineers who would regard themselves as amongst the most highly qualified in the land.

One of the reasons for the present inadequacies in knowledge was that Universities had dropped noise as a subject before the turn of the century, on the grounds that Lord Rayleigh had covered it thoroughly. Indeed, he had done a great deal but had certainly not done it all. Mr. Dawson regarded it as extremely regrettable that people were graduating with excellent degrees in engineering but without having covered noise or acoustics in any way during their course.

He agreed that one of the things the Society could usefully do was engender greater awareness of the problem in both schools and universities and help to establish a real educational programme on noise.

MR. E.J. CUTTING said that he was concerned to raise the level of education regarding the need for good maintenance of vehicles. Hylton Dawson had referred to the desirability of vehicles being maintained to aircraft standards, but Mr. Cutting felt that simply to secure common sense maintenance would be enough.

Britain was one of the few countries in Europe that had no roadside noise control. In Germany, France and The Netherlands, vehicles were stopped and noise meters were positioned behind the vehicle (slightly to one side): the noise level was measured by running up the engine while stationary,that is without any load on. That noise level was then compared with the figure quoted when the vehicle was type approved for sale in that country. Were the figure recorded at the roadside to be significantly higher than the one in the type approval document, the lorry driver or car owner would receive a ticket which meant that he had to get the vehicle fixed within a given period, and then resubmit it for approval. There was no similar procedure in the UK, which could be one of the reasons for the traffic noise problem in this country.

MR. D. BIRD (NSCA Yorkshire and Humberside Division) said that complaints were rising in all areas of pollution, not just noise. That trend had shown up in the past few years. There was a general tendency for people to be more aware of their environment, and the complaints were symptomatic of that trend. He asked the speakers to comment on the tendency of the Courts, first to demand technical information in the presentation of cases relating to noise control and then generally to fail to understand the information once presented.

Regarding the silencing of vehicles, David Bird said that he doubted the oft-quoted reluctance of the general public to pay what was a relatively small cost for a quieter vehicle. Usually the buyer did not appreciate the reason for the various relatively small increases in the overall price of a new vehicle. Were the motor manufacturer to tell him that the small increase was for a new fascia, rather than for increased noise control measures, the customer would be perfectly satisfied.

Mr. Bird considered that there was room for improvement in the MOT and the certification and testing of vehicles. All too often, he felt that the interest of those conducting the tests was far more given to non-environmental matters, and that noise and emissions were given inadequate consideration. He thought that perhaps local authorities should be involved in monitoring and enforcing noise standards applicable to all vehicles, and smoke standards particularly as applied to lorries.

Turning to the subject of measurements, Mr. Bird said that his authority, Sheffield City Council, had adopted an approach which had been agreed to by the local Courts. People were encouraged to deal with domestic-type complaints themselves through the Courts, following an agreed procedure. With the current level of resources, there was no way that Sheffield City Council's Environmental Health Department could investigate and deal with all the complaints about domestic noise. They encouraged the complainants to present their own case on the evidence of their own ears.

Mr. Bird's final observation and question related to British attitudes towards motoring, noise and emissions from road vehicles. He said that most British motorists drove too fast, without regard for noise output or exhaust emissions. He considered that a public education exercise, on how to use the environment more sensibly, was required. That might lead to a less polluted, and a safer, environment.

MR. CUTTING, replying to the point raised about the cost of the vehicle in terms of features or measures for noise control, said that people bought commercial vehicles to perform a function which, hopefully, would result in profit. People bought cars not merely for transportion, but also to satisfy a side of their ego, as the BMW and Jaguar owners in the audience would understand. It was the practice within the motor manufacturing industry to tell their customers when prices were to be increased due to a change in legislation. (He hoped that somebody would ask him a question about catalysts and lean burn engines later, so that he could expand on that point).

Turning to the testing of lorries, Mr. Cutting said that lorries in the UK were tested annually in Government inspection stations. There were some 97 of these stations around the country. The lorries were not tested by the industry or by the dealers. Thus, any question about the inadequate testing of lorries should be put to HM Government's Department of Transport.

On smoke emissions, Mr. Cutting said that one of HM Government's Vehicle Inspectors had told him that, were he to test every bus and coach in the country for smoke emissions, he could take 50% of them off the road straight away, and all of them within three months. As far as smoking diesel engines were concerned, local authority bus corporations were the worst offenders in the country. Somehow, the message had to be got through to the transport authorities. There was no reason for this situation, since the cause of smoke in diesel engines was invariably wrongly set fuel pumps. If the fuel pumps were wrongly set, causing smoke emissions, the vehicles were consuming too much fuel and therefore money was being wasted.

Referring to the attitude of vehicle users, he thoroughly agreed that more education was required. The speed limits in the country were, in many cases, honoured in the breech.

MR. S. TURNER said that many of the points raised by Mr. Bird boiled down to the problems imposed by limited resources.

Turning to the question of presenting technical information to the Courts, Mr. Turner said that the acoustic profession was, to a certain extent, guilty at times of complicating the issue. The subjective response was important, and was fully taken into account by the profession. Unfortunately, not everybody comprehended all the terms used in describing noise, thus it might be better for the Courts to rely on the expertise of the professionals, and accept their judgement on technicalities. The profession needed to become better at explaining matters in simpler terms but with noise being such a subjective matter, and so dependent on many factors, the problem could not easily be resolved.

With reference to domestic noise complaints, Mr. Turner said that the whole question of sound insulation in converted dwellings had arisen because it had gradually been realised that the complaints were not due to unreasonable behaviour by neighbours, but were due to intrinsic physical faults in the building. It was impossible to get to grips with that kind of problem unless objective measurements were taken. By making such measurements, the problem was at least part way to being solved. If it was a matter of two neighbours in dispute because they did not get on with each other, then obviously the persuasive subjective approach was the answer. Nevertheless, local authorities had to be aware that that might not be the nub of the problem: that, indeed, there might be a fundamental structural problem to be resolved.

MR. H. DAWSON said that Mr. Bird's remarks had highlighted the importance of education, and he himself believed that it was impossible to over-emphasise that aspect.

Mr. Dawson agreed that there was scope for more activity on noise control at local level. A few years previously, Southend had had a Chief Constable who had been very keen to control noise. For several years, his had been the only police force in the country that had actually monitored roadside noise, and used existing regulations to take what had been, sometimes, draconian action against offenders.

On the question of the Courts and technical language, Mr. Dawson said that all sides were a bit guilty on that score. Acousticians loved to use their abstruse technical language and to play with the technical tools of their trade. Some years previously, Mr. Dawson had been involved in a case concerning a dairy in London which had caused a local nuisance with milk crates rattling at 5 o'clock in the morning. The complainants (the dairy's neighbours) had hired an acoustics specialist who had talked about the problem in very old units called phons. Someone else had been called to give evidence in court, and he had referred to the problem in dB(A). Someone else had talked about noise criteria. All those specialists had received a fat fee for their pains, but in the end the judge had remarked, "I'll tell you what we'll do. We shall all get up at 4 o'clock tomorrow morning and listen to the noise ourselves".

The case had been solved on those terms immediately.

Mr. Dawson said that he had been most intrigued by David Bird's comments on Sheffield's "Do-it-yourself" kit for noise complaints. Mr. Dawson strongly favoured that approach, rather than relying on officials to sort out each and every problem. Obviously, the ideal solution would be for neighbours to sort out such complaints and disputes amicably, but if people could not live together and be good neighbours, it was up to them to take action on their own behalf and use the law to protect themselves.

MR. G.H. VULKAN (GLC, Scientific Services Branch) had a question in relation to the effect of low frequency noise, and the possible effect of present regulations on vehicle design. Present noise limits were set only in what he termed the "much maligned" unit of dB(A). Much could be said in favour of dB(A), which, as measured outdoors, approximated very well to the response of the human ear. It emphasised the higher frequencies, and gave less emphasis to the low frequencies, just like the human ear. Unfortunately, the unit could also be misused, and in Mr. Vulkan's opinion dB(A) was being misused in relation to noise limits on vehicles.

As Mr. Dawson had mentioned earlier, low frequency noise travelled further than high frequency noise. It also penetrated buildings more easily, via windows and even double windows. Once inside a building, it could set up reverberation. The principal aim of measures to reduce noise in towns was, in fact, to reduce the level of noise inside buildings. Thus, with vehicle noise limits expressed only in terms of units which de-emphasised the low frequencies, there might be a temptation for manufacturers to concentrate on cutting down the high frequency noise emission, and not bother at all about the low frequency noise from vehicles. That would enable them to meet the national and EEC limits, which were framed only in terms of dB(A). Yet as far as the poor listener inside the building was concerned, the noise could well be just as bad.

He asked for the speakers' views on whether there was a real danger that manufacturers might behave as he had suggested, because the current regulations really ignored the low frequency element of the noise from vehicles.

MR. CUTTING said that motor manufacturers were not ignoring the low frequency end of the noise spectrum. Their problem lay in trying clearly to define exactly which area of the low frequency noise emission was causing the majority of complaints. Manufacturers were trying to ensure that the low frequency noise did not worsen, to become a greater problem. At the same time, they were trying to secure clear reductions in terms of the dB(A) scale.

As people would be aware, the EEC had agreed to some substantial reductions in noise output from new vehicles, and motor manufacturers would have to meet a new limit of 84 dB(A) (for HGVs) in about five years' time.

The United Nations' Noise Group had been looking for some years at low frequency noise. In spite of the existence of the dB(C) scale, which took account of low frequency noise, no-one had yet defined a set of parameters which would specify the point at which the problem began. In his view, it would be helpful for a reputable research group to try to define the onset of the low frequency noise problem, and to define this not merely for British road conditions, but for the Continental situation as well. The Swiss had looked into the problem some years previously, and had concluded that the only solution lay in paying out grants for secondary glazing for all dwellings which actually fronted roads which were major truck routes and even, where necessary, to pay for the realignment of the house, so that the rooms which faced on to the noise path were those used in daytime rather than at night.

MR. C.G. HOWELL (Stroud D.C.) said that his comments concerned the three elements of co-operation, education and aircraft noise.

He had been delighted by Hylton Dawson's reference on page 9 of his paper to the fact that "Environmental Health Officers did it better" (which would make a marvellous car sticker), in comparison with the acousticians who had let politicians down in the USA by making unworkable recommendations for steps to control noise.

However, referring to Mr. Dawson's second point that pre-emptive measures would never work until there was really good co-operation between the Environmental Health Department and the Planning Department of local authorities, and the developers, Mr. Howell wished to disagree gently with the implications of that comment. In his own authority, there were excellent relations between the two Departments, and he considered that the planning department had, since local government reorganisation in 1974, paid increasing attention to what their environmental health colleagues had to say on noise matters and the mistakes of the past were not recurring. He felt that his view has been borne out by the statement in Mr. Turner's paper about the involvement of environmental health experts in development work:

> "Private sector development is also being controlled by use of the planning powers. Negotiations between the developer and, usually, the environmental health department result in some treatment being used."

Mr. Howell also wished to take issue with Mr. Dawson's comment that, until such time as legislation and technology had improved, intensive efforts should be made to improve public education on the subject of noise. He wondered, perhaps provocatively, whether it was really wise to carry out such a massive educational programme before improved legislation and technology was a reality. It might be too great a challenge to existing resources, in both financial and manpower terms, to have a vociferous and demanding public clamouring for ever-higher standards (however desirable those might be) being even more frustrated at the lack of effective action. That could bring the environmental health profession, quite unfairly, into disrepute, alongside politicians, acousticians and planners. It was a chicken and egg situation.

Finally, referring to Mr. Dawson's suggestions about areas which the Society's new Noise Committee could consider, Mr. Howell asked that two more items might be added to the list under the heading of aircraft noise. These were sources of real annoyance which he felt could only be controlled by the introduction of new legislation. The first was the use of private helicopters, which landed on the lawns of successful business tycoons at all hours, to the distress of local residents. The second was the almost continuous noise from "tug" aircraft, towing gliders into the air from local aerodromes. The noise from private aircraft and private clubs generally was a source of nuisance. Both the specific sources he had mentioned led to numerous complaints in his own district. He thought that possibly other parts of the country were similarly affected.

MR. DAWSON, replying to the point about co-operation, said that he was delighted to learn about the excellent relations between the environmental health and planning departments in Stroud. He would similarly applaud that trend if it manifested itself throughout the country. Speaking as an "oily-handed engineer", he said that people had to remember that he was still picking up some of the pieces from the past mistakes, and perhaps could be forgiven for having a long memory about the lack of co-operation in the past. That might have misled him into thinking that there had been less improvement than Mr. Howell had indicated.

As to whether or not education might be a double edged weapon, Mr. Dawson agreed that it certainly could be. Nevertheless, he did believe that a programme should be begun at once, since it would raise the level of awareness to the desired point, which would in itself help to move things forward. Also, many noise problems did not require a high technology solution or legislation to overcome them. They required the elements of awareness and consideration, and in his opinion it would be highly desirable to have more of that throughout society. In a more limited context, improved education might stop people from buying the wrong plant - i.e., wrong from the acoustic viewpoint. He had recently been delighted to read some literature about Japanese garden equipment, which had quoted the noise level in dB(A) at five metres from the machinery. That information gave people some idea of what they were buying in terms of noise output, and it would be desirable for manufacturers in the UK to adopt the same practice in their advertising literature. While education needed to be handled with some sensitivity, he still felt it to be most important.

Turning to the recommendation that the Society's Noise Committee should look at the problems of private helicopters and "tug" aircraft, he said that the Committee would look at whatever was brought to their attention. The Committee would keep its feet firmly on the ground in the sense that it would bear in mind political, economic and social constraints, but would press for whatever reforms it considered necessary.

MR. TURNER, harking back to secondary glazing and low frequency noise, said that one of the ironies of the situation was that secondary glazing was least effective at the low frequencies and most effective at the higher frequencies! Thus, it certainly was not the total answer, although it helped a bit.

Turning to helicopters, he said that they were one of the major problems in London. The GLC had got to grips with the problem and were one of the leading authorities in exercising controls to ensure that the situation did not get out of hand.

The GLC had opened a complaints noise line, which had had its busiest time when racing had taken place at Brands Hatch. Most of the complaints concerned helicopters which had been ferrying people to Brands Hatch from all sorts of new locations within London. That helicopter airlift had been a sort of one off exercise under the 28 day rule, which allowed helicopters to be operated from a site for 28 days in any one year without any formal planning consent being needed. At the moment, the GLC and other authorities were stuck with that rule. However, for the future, he recommended authorities to use their planning powers wherever possible to control the number of helicopter movements and the type of helicopter used, so that at least the impact on residents within their own and other areas where the helicopters landed, would be minimised.

Mr. Turner entirely supported the need for an educational programme and thought that it should begin straight away. He thought that there would be quite a difficult hump to overcome initially. For example, care had to be taken when specifying noise output from newly ordered, purpose-built equipment (as for example had recently been done for the GLC's fire service) that the requirements were not too stringent. In that case, manufacturers might refuse even to try to meet the specification.

However, he agreed with Mr. Dawson that there were many simple modifications which could be made, and it was a question of simply bracing oneself to overcome those first hurdles. If the demand for quieter equipment and machinery was widespread, then he was sure that eventually the desirable noise reductions would be achieved.

MR. J.H. BODDY (Individual Member, NSCA) had a question related to the high compression lean burn engine to which Mr. Gould had referred. In his comments, Mr. Gould had remarked that the HCLB engine did not require lead, and Mr. Boddy asked him to expand on that remark since he thought that the relationship between that type of emission control and the quality of the fuel that would be required was important.

MR. D. GOULD said that he had in fact meant to indicate that the lean burn engine was not dependent in any way upon, or affected by, the presence or absence of lead in petrol. On the other hand, catalysts were largely dependent on using unleaded fuel. People who misfuelled their engine when the car was fitted with a catalyst, could well so damage the catalyst that it would cease to be effective. That problem did not arise with the high compression lean burn engine. One of the options he had mentioned for emission control was the HCLB in conjunction with an oxidation catalyst. At present, that catalyst was lead sensitive, but was less so than the so-called 3-way catalyst used in the current US system.

In summary, the removal of lead from petrol would not be a factor in the operation of the high compression lean burn engine, whereas it was a precondition for the use of most catalytic controls.

MR. BODDY asked if Mr. Gould could suggest what octane quality would be required for the lean burn engines.

MR. CUTTING said that octane quality did not matter very much to the lean burn engine. Unleaded petrol was almost certain to be 95 RON (85 MON). He explained that there were in fact two octane numbers in petrols, according to two different test methods. The figure usually displayed at the petrol pump was the Research Octane Number which was the higher of the two octane numbers. From the vehicle engineer's point of view, the Motor Octane Number was almost always more important. At present in the UK, premium or super petrol was 97 RON and contained 0.40 grams of lead per litre of petrol. That level would soon be reduced to 0.15 g/l. Were the European Commission's proposals for legislation to introduce unleaded petrol to be carried (and the Ford Motor Co. was very much in favour of this move) then motorists could expect unleaded petrol to be available at the pump from about 1987 onwards. From October 1989, only cars that could run on lead free petrol would be permitted to be approved for sale. That applied to type approval for new cars. New cars under existing model lines could continue to be produced for consumption of leaded fuel until 1991. In 1991 all new cars would be required to run on lead free petrol.

The unleaded petrol would come down to 95 RON which would make for a small loss in fuel economy. However, the lean burn engine was so much more economic than today's engines, that that small loss would never be noticed since there would be such a significant overall improvement in fuel economy - about 14-15%.

MR. J. CLEGG (Bolton MBC and Manchester Area Council for Clean Air and Noise Control) wished to question Mr. Turner further on the conversion of dwellings and sound insulation measures. He said that local authorities in the Manchester area had early on perceived the trend for conversion of larger dwellings into flats, and had recently encapsulated their own experience, and that of other authorities such as the GLC, into a document which would be put before the MACCANC Council at the end of the month. The guidance dealt with three aspects of conversion. First was protection of existing neighbours against noise from new flats. The second concerned the protection of flat dwellers against noise in other flats, and the third aspect was the protection of flat dwellers against external sources of noise, such as transportation and industry. He anticipated that the document could shortly be obtained from the Secretary of MACCANC at the Environmental Health Department, Town Hall, Manchester. He asked Stephen Turner whether, in the light of conflicting planning decisions by the Department of the Environment in respect of conversions and noise insulation, he was aware of any standard DOE advice, or indeed of any DOE interest in the subject.

MR. TURNER said that as far as he was aware, the extent of DOE's interest in the subject had been the work carried out three or four years earlier by the Building Research Establishment, which had produced the "independent ceiling method" of acoustic control. As he had indicated in his talk, that was not the whole answer, and other steps had to be taken. The Building Research Establishment had subsequently added to their design solution the floating floor, but even with that adaptation, Mr. Turner did not consider that they had wholly solved the problem.

Regarding legislation, Mr. Turner regretted that the draft Building Regulations had still ignored the problem of sound insulation in converted dwellings. Conversions still appeared to have been exempted, which meant that the local authority had no clout in that direction and would still have to use planning laws somehow.

He considered that a local authority would be ill advised to require developers of existing dwellings to meet the standards laid down in the Building Regulations for new properties. That could lead to problems with listed buildings where there might be limited ceiling height. Nevertheless, he strongly recommended local authorities to find some way of requiring the incorporation of those methods of sound insulation that already existed when private developers applied for permission to convert existing dwellings. He considered that present techniques did offer scope for considerable improvement over developments which took no account of noise insulation. In his opinion, it would still be quite some time before sound insulation for conversions was specified in the Building Regulations, hence the GLC's proposal for the data bank and their efforts directed at finding the all-purpose, cheap and reliable solution.

SESSION SIX

ASBESTOS - THE 1984 PERSPECTIVE

ASBESTOS - THE RISKS OF EXPOSURE

Dr. M.J. Gardner, MRC Environmental Epidemiology Unit, Southampton General Hospital

ASBESTOS - SAFEGUARDING THE NATION

S. Grant, Health and Safety Consultant

ASBESTOS - ADVISING THE CITIZEN

P.A. Alcock, City of Manchester

MR. T. TOWNSEND (Midlands Joint Advisory Council), opening the discussion, explained that the organisation which sponsored him at conference, the Midlands Joint Advisory Council, had a specific remit of concern for air pollution and noise related to the general external environment, outside the workplace. When the Advisory Council had recently held a one day seminar on asbestos some of its members had objected that asbestos was a problem of health and safety in the workplace, not an external air pollution one. However, since both the National Society for Clean Air and the Warren Spring Laboratory-organised Standing Conference of Co-operating Bodies, both of which were similarly primarily concerned with the external environment, considered it appropriate to debate the issue, Mr. Townsend felt that the Midland Joint Advisory Council's decision had been correct. Yet having listened to the first two papers he wondered whether in fact there was a problem!

Putting his first question to Mr. Alcock, Mr. Townsend said that a young Environmental Health Officer in his Department had recently bought a house and was carrying out major improvements to it. He had decided to take down a plaster and lath ceiling and had found insulating material behind it, which (following analysis by his Department) proved it to be almost entirely composed of amosite asbestos in a particularly loose and dusty form. Following the advice of the Department the Officer had called in three licensed asbestos removal contractors. The least expensive quote for removing this asbestos from the loft had been £760, although one of the contractors had suggested that the Officer should remove the amosite himself, wearing a mask, and bag up the material in plastic sacks, which he should then take to the Civic Amenity site. Mr. Townsend asked Mr. Alcock what advice he would give to an ordinary member of the public in a similar situation.

For Mr. Grant he had a very personal question. Mr. Grant had explained that he had, during the course of his work as a factory inspector, walked through clouds of asbestos dust. Mr. Townsend asked him, in the light of this, whether he in fact was concerned about his own health and whether, for example he thought he had run the risk of developing a mesothelioma in the next ten or so years.

Mr. Townsend said that Wolverhampton had established a specialist section to deal with asbestos and his own practice was on occasion to require his specialist inspectors, properly equipped, to enter the tent where stripping was taking place to check on contractors' working practices. Despite taking the necessary precautions, including proper decontamination procedures, the local Health and Safety Executive Inspector had raised doubts as to the advisability of this practice. The Inspector had explained that it was the policy of the Health and Safety Executive not to expose their own staff to possible contamination and that during the past four years he himself had only been inside a stripping tent on one occasion. Mr. Townsend asked for Mr. Grant's comments, particularly in the light of his earlier statement that it was necessary to enter the tent to see how the stripping work was being carried out. Another question for Mr. Grant concerned the "balling" of asbestos cement roofs during demolition operations. As Mr. Townsend understood it, current HSE guidance required this method, which involved dropping a large ball onto the asbestos roof to break it up, rather than require men to remove the sheets manually (the latter method putting the workers at risk of falling through the roof).

The final question was to Dr. Gardner, who had said that the risk of developing lung cancer was proportional to the duration of exposure. Whilst accepting that point, Mr. Townsend wondered what Dr. Gardner's views were on the other hypothesis, that a very high exposure for a short period could be significant. In that context he wondered whether the type of exposure that his young Environmental Health Officer might be exposed to, were he to strip out the amosite insulation from his loft with only limited or inadequate protection, would be significant.

He also asked for Dr. Gardner's comments about the possible exposure of children to asbestos.

MR. P. ALCOCK, replying jokingly at first to Mr. Townsend's question about advice to his student officer, said that he would undercut the quote from the licensed contractor by £260 and do the job for £500! More seriously, he said that without in any way intending to be political, he considered that central government was still giving very inadequate consideration to the problem of asbestos in the domestic situation. Several local authorities were trying to deal with asbestos in homes, but most simply did not have the funding to do so effectively. Until central government made funding available for that type of work, he did not consider that Mr. Townsend's colleague would get a satisfactory answer. It would be extremely hazardous for the student officer to attempt to remove the amoside; Mr. Alcock said that he would not actually attempt to do anything like that himself because of the risk. He did not have the equipment, the back-up or the experience necessary to do the job properly. Very few contractors were sufficiently well equipped, or sufficiently competent to protect themselves, the householders and other people in the area. Contractors had to be careful not to pollute the whole of the environment.

The only real advice he could give was to tell Mr. Townsend's colleague to refuse the contractor who had bid for the job with a quote of £760.
In Mr. Alcock's opinion, the job could not satisfactorily be done for less than £2000.

MR. S. GRANT, replying first to the same question, said that without seeing the situation he could not really offer positive advice. The remedy, depending on the amount of ceiling already removed, might be to seal the asbestos in place, boxing it in from below, and sealing very carefully the ceilings beneath. It would also be necessary to identify and mark the presence of the asbestos. That would be the first and cheapest option, if it were practicable.

Mr. Grant said that it was certainly very useful to be able to project oneself into the situation, which he could do in terms of having walked through clouds of asbestos dust in the 1950s. However, he had no worries whatsoever about his own health since the amount of time he had spent in those factories was so small. Time weighting the risk, he estimated it to be negligible. On his personal scale, a risk mattered when it projected above the risk of getting out of bed in the morning!

Mr. Grant said that he had been aware that some HSE Inspectors did not go into the stripping tent to keep an eye on asbestos removal operations. In his opinion, that fact reinforced his comments about stripping operations. Some inspectors might go inside the tent on one or two occasions, but there were nowhere near enough inspectors on the ground to do the job properly even if they were all advised to enter stripping enclosures in that way. He said that he would himself, if properly kitted out, be prepared to go in and observe the stripping in operation. However, he made it clear that he would prefer not to wear a fit type respirator. He regarded fit type respirators as obsolescent and said that the sooner everybody moved on to wearing proper hoods with an air supply, the better.

Turning to the question about removal of asbestos cement sheeting, he said first that asbestos cement was a relatively safe form of material, with an asbestos content of about 10%. Generally, that asbestos would be chrysotile (although not always). In the main, the asbestos was locked into the structure of the material and could not easily be released without bashing it up and grinding it down. However, his first choice would always be to strip the asbestos sheeting off rather than balling it. He thought it preferable to get the asbestos off the site before balling commenced as part of the demolition process. In his opinion, that should also be the first choice of HSE. The choice of method might depend on the situation of the building to be demolished and on the precautions that the demolition workers themselves would take. It might be that there were situations, particularly where workers would be at risk, where balling would be a preferable method.

DR. M.J. GARDNER confirmed that duration of exposure was important in relation to the onset of lung cancer and said that he had illustrated the point with results from animal experiments. It was also true that the concentration of exposure was important. During his presentation, he had shown a diagram of results from his study of amosite workers, which revealed that people with very heavy exposures got much more lung cancer than people with only low exposures for the same duration of work. Thus, both duration of exposure and fibre concentration independently contributed to the risk. The usual way of demonstrating those two factors jointly was, as Stephen Grant had mentioned, to consider a time weighted (cumulative) exposure. He asked the audience to cast their minds back to the dose response diagrams he had shown for three different industrial groups, which had shown the risk of lung cancer against (concentration x time) measure of exposure. Both measures had to be considered in assessing the risk.

Turning specifically to the question of whether or not two days of high exposure to amosite would produce a risk of mesothelioma, Dr. Gardner said it was difficult to give a complete answer without knowing the concentrations involved, but in his view, unless the concentrations were massive, the risk would be small. Alongside the other risks of life, it was the sort of risk that people faced every day without any concern at all. Nevertheless, it would be neither fair nor true to say that there was no risk. The truth was that there could be a risk of developing a mesothelioma after very small duration, and very small concentration, exposures. Sometimes people got the wrong perspective on the development of mesothelioma. For example, he had shown during his presentation a map of the distribution of pleural mesothelioma in England and Wales, and about 60% of the cases occurred in the small number of areas identified on the map. Those were mesotheliomas occurring in the 1970s and were related to the specific location of the individual in the 1940s. Britain had a fairly mobile population, and some people who had been exposed to asbestos in, for example, Barrow-in-Furness may have since moved away from the area. What he did not yet know was how many other cases of mesothelioma around the country had their origin in exposure in such locations (elsewhere) in the 1940s, i.e. how many people there were who had moved away to die in other parts of the country. At present, an effort was being made to establish what percentage of the mesotheliomas were related to occupational exposure, rather than to short duration exposure. Dr. Gardner said that Mrs. Nancy Tait of SPAID (Society for the Prevention of Asbestosis and Industrial Diseases) was deeply concerned that some of the mesotheliomas she had seen or heard about had occurred in people with no known history of industrial exposure. That was obviously a very genuine cause for concern, but it had to be recognised that it was extremely difficult to obtain a complete history of workplace exposure over a period of perhaps 40 years.

From a statistical point of view, the mesotheliomas that occurred as a result of low exposures were the outcome of a very small risk in the large majority of the population. The mesotheliomas that occurred from very high exposures were the result of a high risk in a very small percentage of the population. Thus, some cases would be expected amongst people who had not been heavily industrially exposed to asbestos, because there were so many of these people - probably 95% or more of the total population. However, it was important not to get those cases out of proportion in terms of relating it back to the risk.

Thus, in response to the question of the two days' exposure to amosite, Dr. Gardner said there was no real answer, and that the risk if it existed was unquantifiable but likely to be small.

Turning to the subject of children, Dr. Gardner said that the risk of children's exposure to asbestos in schools had been widely studied in the United States, and had received some study in the UK. None of the scientifically valid papers which he had seen justified the degree of concern that existed about the exposure of children in schools and other buildings.

DR. F.E. SHEPHARD (Institution of Gas Engineers) said that people might derive comfort from his history of exposure. He had smoked for 20 years before giving up, he had worked with asbestos, carbon tetrachloride, benzene, mercury - and he was pleased to report that the statisticians had left him a little gap to get through in the next few years!

He considered that the presentations that morning had given a balanced view of the problems associated with asbestos. He agreed with the recommendation to seal asbestos wherever possible (when it would not be disturbed by vandals). It was the obvious solution. The NSCA's reputation was based on its good, well-informed views, and its use of that information to make progress. In respect of asbestos, Dr. Shephard said that it was necessary to adjust the level of dread to the level of risk. Many pressure groups were taking the extreme position, that in each and every situation every bit of asbestos had to be removed, and that all operations and situations had to be monitored. He asked for the authors' views on how the true facts could be communicated to redress the balance somewhat. Mr. Alcock had given some ideas on how this could be done with the general public, but Dr. Shephard considered there was another route, through the Trade Unions. Many of those in the room would be members of trade unions, and could use their knowledge to secure a more balanced view on the risks and on what should be done about the risks, via their unions.

Referring to Mr. Grant's presentation, Dr. Shephard said that it had suggested to him that controls were carried out very differently in Sweden, with the standards being achieved using different means. He asked for Mr. Grant's comments.

His final question was related to the recent massive fire in London in which asbestos material had been involved and had been widely dispersed. He wondered how such situations could be controlled, and how public concern about such incidents could be allayed, or whether indeed it was a genuine cause for concern.

MR. ALCOCK said that perhaps the real problem was education, rather than communication. Communication was based on three principles: first to tell someone what you were going to tell him, then to tell him, then to tell him what you had told him! But the problem lay in how people perceived the information that they received. To a certain extent the same difficulty applied in the field of education, the purpose of which was both to inform, and to develop an individual's ability to use information and analyse it for themselves. The stumbling block in helping the general public to appreciate the dangers of asbestos in a proper perspective was that the public were on the receiving end. The perception amongst members of the public was that they would be the ones to suffer.

Mr. Alcock did not believe it would be possible to persuade people otherwise.

All he felt that any professional or reputable body could do, would be to state clearly what the position was at that particular time, set out the current scientific and professional opinion but also warn that those opinions could change the very next day in the light of new evidence. That was less than satisfactory, but probably the most honest response.

Turning to the distribution of asbestos fibres after fires or explosions, Mr. Alcock said that his real concern was the distribution of asbestos fibres following the demolition of buildings. He tended not to disagree with Mr. Grant over his recommendation to seal asbestos within a roof space, but it was a very difficult thing to do, and it has to be remembered that with the air sealed out of the roof space, dry rot could develop in the timbers. Eventually, the buildings would have to be demolished; sooner or later the asbestos would have to be removed. In his opinion it would be better for it to be removed sooner rather than later. But, referring to the distribution of asbestos fibres over a wide area, he recalled one occasion on which he had remonstrated with a safety officer who was allowing men to break up asbestos cement sheeting into very small pieces. The safety officer had replied by saying that there was no need to worry since there was a high wind which would quickly pick up, carry away and spread the fibres! Statistically, scientific, and medically, perhaps asbestos was safer when spread and diluted over a wide area, but the same theory had also been used in respect of other air pollutants, and the disposal of sewage sludge at sea. In most cases the thinking originally had been that the pollutant material would be safely dispersed by being spread and diluted within a large mass of air or water. Eventually, however, that process could not continue for lack of sufficient dilution air or water.

In summary, he could offer no solution to the widespread disposal of asbestos in the general environment, and said that the idea of such distribution caused him considerable concern.

DR. GARDNER agreed with Mr. Alcock that the nub of the question was education rather than communication. The only answer was to give the facts, tell the truth - and go on repeating the facts and telling the truth. It was sometimes an uncomfortable and frustrating process, since people often were not receptive to what the "expert" perceived to be facts. He believed that there had been a great deal of distortion in the area of asbestos risks, some of which had come from the media. A priority had to be to educate the media, which was not a view he had held a few years previously. However, since working in the area of asbestos, his view had changed and he was unhappy with reports that were incorrect in terms of the assessment of risks, which distorted the picture and created undue concern among the general public. He now tried to talk to the media when they contacted him, or to contact them himself to try and put the risks into perspective. This was not always successful, and there was a long way to go, but he felt it was worth persevering since he considered that the problems with the public would be greatly diminished once some sections of the media had been properly educated.

Dr. Gardner said he could not really understand (and he suspected that he was not alone) why asbestos had been singled out for such particular attention. For example, coal dust was a massive killer, or had been, of men who worked in coal mines. Silicosis and anthraco silicosis, contracted from the inhalation of coal dust, were in some ways similar diseases to asbestosis. The problem of inhaled coal dust extended outside the mines into homes in which coal was burnt. It was known that children who had been brought up in homes with coal fires developed more respiratory problems in early life than did children who did not live in houses where coal was burnt. Somehow, though, that was not seen to be a problem of the same magnitude, in terms of risk and concern, as asbestos. Indeed, it could be that in terms of risk, coal dust presented a greater risk to children than did asbestos. The answer might lie in the fact that coal dust was visible and visibly present - it dirtied the curtains and furnishings in the home so its effects could be seen.

MR. GRANT said that he entirely agreed with that view. Some two years earlier, when he had been Scottish Director of HSE, he had decided that the Executive should go on the offensive, and should not merely lie down under the weight of silly statements from the media and the panic created amongst the public.
He felt that he had begun to see some results from his efforts. He thought that, certainly in Scotland, people did not make silly assertions to the same extent as before. He advised people, from his own experience, not to be defeatist, but keep on telling the truth and to project themselves into the situation. Mr. Grant said that he was quite prepared to tell people that, while he might not like living in a high rise flat, from the asbestos point of view he would be quite prepared to take his family and live in their flat because, as far as he was concerned, there was no measurable risk.

Turning to the question about Sweden, Mr. Grant pointed out that in many respects Sweden was a very different country, with a smaller population and a different industrial base. In general, the Swedes took environmental matters far more seriously than people did in the UK. There was in fact only one asbestos factory left in Sweden, making friction material for brake linings. That factory was spotless, so that although their numerical standard might be less stringent than the UK's, in practice the record was faultless. The exhaust systems were under constant watch. Unlike British practice, the factory workers there were not on piece work and the company made far more profit than its British equivalent. It was simply better managed. If a Swedish worker had a two minute break in his production cycle, instead of smoking, he would take the vacuum equipment which was ready to hand and clean a floor or a trolley which, to most eyes, was already clean. In general, there was a totally different attitude towards health and safety matters in Sweden. There was a level of co-operation from work people which simply did not exist in the UK.

Mr. Grant said that the fire contamination incident had amused him almost as much as the sight of people in space suits looking at the asbestos seal on gas oven doors. He thought it quite absurd to see people in space suits walking around looking for bits of asbestos on the pavement or in the fields which had fallen out after a fire in some building. First of all, he would pray for a shower of rain. He personally doubted whether the risk could be measured. For a start, the fire might have degraded the asbestos so that it would not be in the same dangerous state that it would have been had it merely been distributed without a fire. Secondly, the fibres would be so well distributed that it would be almost impossible to measure the level of contamination or the risk. Again, he thought it was necessary to return to common sense evaluation, using the eyes for a visual examination of the situation.

MR. ALCOCK said that he entirely accepted Mr. Grant's opinions on the widespread distribution of asbestos, but his own view as an EHO in direct contact with the general public was that people were more likely to be panicked if nothing appeared to be done by officials to assess the situation, than if they were seen to be doing something. That something could, in scientific terms, be almost useless but was necessary to allay public anxiety. From his own experience, major panic occurred when officers sat back and told people not to worry.

MR. GRANT agreed that officials had to be seen to be responding to the situation, but they did not necessarily have to be equipped with space suits!

DR. M.J.R. SCHWAR (GLC, Scientific Services Branch) wished to comment on non-occupational exposure to asbestos. Referring to the arousal of public anxiety, Dr. Schwar said that the very terms used by the speakers that afternoon - "no measurable risk, negligible risk, not quantifiable" etc. - were those which created public concern. Such terms meant nothing to the general public: they were not quantified.

Granted that it was difficult to measure levels of asbestos in the general environment, Dr. Schwar nevertheless reminded the speakers that previous sessions of the Conference had heard about the use of models as an aid to the decision-making process. In his opinion, it would be very helpful were officials to try to express risk, rather than to use loose terms such as "very small risk, almost negligible risk", in the form of a number of excess incidences of asbestos related diseases. Accepting that not all the facts were yet known, Dr. Schwar said that at least an attempt could be made to give ball court figures of upper and lower limits. The experts should come out into the open and be specific about the orders of magnitude, quantifying the risk by saying that they were very much smaller than many of the everyday risks that people were exposed to. What was required, in absolute terms,was a statement on numbers of people per million of population who might be suffering excess risk due to asbestos exposure.

In order to do this, information was required on ambient levels of asbestos, particularly in relation to buildings. Figures had emerged from Germany that in buildings with asbestos in a poor condition measured levels were in the order of 0.005 fibres per millilitre. Dr. Schwar asked Dr. Gardner if he had any information on the circumstances in which those measurements had been made and the methods used to make them. He himself had experience of situations in which asbestos debris had not been visibly present, and the measurements showed readings below 0.01 f/ml, and there had,to his knowledge, been no disturbance of the surface dust during the measurement. Yet, repeat measurements had shown concentrations that were significantly higher, sometimes as high as occupational exposure levels when surface dust disturbance had taken place, such that residual fibres that had settled out were made airborne.

These results led him to fear that there could be situations where areas, deemed to be clear, in fact contained levels of asbestos as high as the occupational exposure limits, and that that level of contamination could persist for a considerable period - many months or even longer. No-one knew how many such cases of contamination might exist. He therefore asked the speakers two questions. First, whether they could talk in specific terms about ranges of actual measured concentrations found indoors. He wanted figures that the speakers had seen, scrutinised, and which they recognised as reliable, rather than hearsay (of which there was far too much in connection with indoor asbestos levels). Secondly, he wanted information in absolute terms on the likely excess deaths due to asbestos related diseases contracted by people exposed in such situations.

DR. GARDNER said that he quite took Dr. Schwar's point about the need to quantify the risk more exactly. While he had not done so that afternoon, in their work for the Advisory Committee on Asbestos Dr. Acheson and he had tried to do exactly that - to estimate, using models, the number of deaths amongst the general public due to either indoor or outdoor exposure, that could be said to be due to that exposure. The assumption was that the exposure was over 50 years, at the levels found outdoors or indoors. For example, referring to the calculation of the number of lung cancer deaths that would occur among one million births, if people were exposed for 50 years to the typical ambient outdoor concentrations (approximately 10 nanograms per cubic metre), he said that about one or two deaths from lung cancer per million of a population could be expected. That figure gave people a very real idea of just how small the estimated risk was. He had already shown in his dose response diagram how different the risk could be in different circumstances, thus the precision with which the risk at such very low levels could be estimated was very small. That was a reason for trying, in fact, to avoid quantified figures, although he thoroughly agreed that it was desirable to produce such figures.

The figures of one or two deaths per million due to ambient asbestos exposure could be compared with the 50,000 deaths per million which would result from cigarette smoking. That comparison provided another perspective on the risk. Yet another perspective was provided from studies amongst occupationally exposed people. These showed that the number of excess deaths from lung cancer among asbestos exposed workers was approximately equal to the total of deaths from asbestosis and mesothelioma. Thus, a total picture of the risk to the general population from non workplace environmental exposure to asbestos could be given by doubling the one or two deaths per million, to arrive at a figure of three or four deaths per million of the population. However, Dr. Gardner warned that although he had done those calculations himself, even he did not have a great deal of faith in them! The difficulty lay in the fact that the figures used were very approximate. Nanograms per cubic metre were translated into fibres per cubic metre and then into gravimetric mass to correspond to the way in which the original measurement studies had been done. That was just one of the problems involved in such calculations. Nevertheless, the type of figures Dr. Schwar wanted were available, and one of the sources was the Advisory Committee's 1978 Report.

MR. GRANT agreed with Dr. Gardner's remarks, and said that when he himself used the general term "negligible risk", he equated it in his own mind with the risk of an individual member of the audience being struck by lightning.

Another point he wished to make was that the experts had assured him that sampling at such very low figures was totally unreliable if done by the normal microscopic methods, i.e. phase contrast optical microscopy.

MR. ALCOCK said that although he had quoted some figures in terms of f/ml in his paper, he would strongly maintain that the public simply were not interested in such figures and statistics. As Harold Wilson had once said in response to a comment that the unemployment level was only 2. something per cent, "Yes, but if you are one of the 2. something per cent unemployed then the rate is 100% for you". The same was true of asbestos. If a person thought his home was dangerous, then he would not really be interested in any assessment or presentation of the degree of risk to which he and his family were exposed.

As his work with asbestos had progressed, Mr. Alcock had become more and more disenchanted with quotations of asbestos levels in terms of fibres per millilitre. He thought that the most important thing was whether or not the asbestos was in such a state that it could release fibres into the air. Measurements would vary from day to day, depending on the occupancy level or use of the building, or outside, upon air currents etc. When people were up to their armpits in alligators, it was easy to forget that the original intention had been to drain the swamp!

CLLR. R. COOPER (Walsall M.B.C.) said that he had a particular problem in Walsall. 1000 tons of asbestos waste was to emerge from a local power station, and he sought advice on where to put it. He was certain that the neighbouring authorities of Wolverhampton and Sandwell did not want it! He asked whether his authority should bury it, put it in caverns, or put it on the local civic amenity site.

His next point concerned monitoring during the stripping operations. The CEGB and the Health and Safety Executive both said that they would monitor the situation, but people in Walsall were not satisfied with that arrangement so Cllr. Cooper had obtained approval from the Finance Committee for the expenditure of £40,000 so that Walsall could carry out its own monitoring.

Recalling that the Secretary of State for the Environment had swum the sea off Windscale to prove how safe it was, shortly before radioactive material had been found on the beach, he said he wanted nothing of that sort to happen in Walsall! He asked the panel how far, in the event of an accident, asbestos dust would be carried in the air around the power station.

Finally he made a plea for the Society to publish a leaflet on asbestos which would set out the facts and provide some measure of reassurance, if possible, to members of the public.

MR. GRANT referred the questioner to DOE Waste Management Paper No. 18 which set out the three steps involved in the safe disposal of asbestos waste. The waste had to be dumped on an approved site, covered immediately with earth, and had to be buried in such a way that when the tip was exhausted, the asbestos waste would be two metres from the surface at any point. In his view, that recommended way of getting rid of asbestos waste was perfectly safe.

MR. ALCOCK said that his authority, Manchester City Council, did publish and distribute public information leaflets of the type requested by Councillor Cooper. It might be possible for that leaflet to be used as an example in drawing up something similar either for a particular local authority or for a more general purpose.

On the subject of monitoring, Mr. Alcock said that from the technological point of view he was extremely unhappy with current monitoring methods. He suggested that any authority trying to monitor a situation such as Councillor Cooper had described would have to monitor the system, and the methods used. It was impossible to monitor release of fibres to the external atmosphere effectively. In any case, once they had been released, it was too late to monitor the situation! Ideally, the local authority should monitor to ensure that the system of work was correct.

MR. GRANT said that he agreed with Mr. Alcock. One of the difficulties of monitoring outside was that the material was so very quickly dispersed and diluted. A large number of samples would have to be taken to ensure a reasonably accurate result over a period of some 4 hours. By the time the fibre was collected, half the urban muck of Walsall would have been collected with it! The fibre would be buried somewhere in the dirt. There were such awful problems involved in environmental sampling that he recommended common sense methods, including smoke tests indoors and the use of dust lamps and visual methods of checking what was happening.

MR. J. EVANS (Rhymney Valley DC) said that from that morning's discussion, and from other meetings he had attended on the subject, there appeared to be very little risk attached to non-occupational exposure to asbestos. He wondered whether the statistics could have been influenced by the fact that until the 1960s there was far less use of asbestos products in homes, offices and public buildings. Today, the occurrence of asbestos in such situations was widespread. Mr. Alcock had mentioned the domestic situation, and had highlighted the problem of warm air heating systems which had received a good deal of consideration in Mr. Evans' own area. His authority's survey had shown that many of the panels surrounding warm air heating units were damaged. The survey also showed that the cabinets were used for storage, not only of domestic items, but for clothing including young children's clothing. In view of that fact, and the fact that the council's own heating engineers often worked, for maintenance purposes, in confined spaces where asbestos material might be present, the authority had decided to adopt an overall policy. Having considered sealing, the council had opted for a policy of removal. He asked for the speaker's comments as to whether or not his council were correct in their course of action. According to what Mr. Alcock had said, he thought that there was merit in it, particularly when the material was damaged.

Commenting on the licensing regulations, Mr. Evans said that he was concerned that various contractors appeared to be offering their holding of a licence as a panacea for all ills. He considered that the licensing regulations might in fact be making the situation worse, particularly for authorities which had not yet set up a specialist unit to deal with asbestos. In his experience, asbestos removal contractors that held a licence often had working practices which left a great deal to be desired.

Mr. Evans also wished to stress the importance of proper training for environmental health officers dealing with asbestos. His own department had been quite confident, having liaised with their own safety officer, and following discussions with HSE, that they had evolved reasonably safe working practices. However, recent advice from the Institution of Occupational Medicine on their procedures had brought to light glaring deficiencies. Thus, he advised other local authorities who were preparing to supervise all stripping operations (as his own did) to ensure that their officers were highly trained, so that they could not only protect themsleves but also the members of the public.

DR. GARDNER, commenting on the question of whether risks were more widespread now than in the past, said that he doubted whether that was so in terms of any major risk. Although the products were widely dispersed, the exposure could not compare in any way with past exposures to dramatically high levels in the workplace. He also considered that practices within the manufacturing industry had improved tremendously. For example, in the asbestos cement industry where chrysotile only was used, the risks (although not negligible) were very much lower than in the past. That was almost certainly related to the fact that it was a wet process, and thus the dust levels were much lower. Thus, there were differences of risks even amongst occupationally exposed people. But even the lowest of those were vastly higher exposures than those to which the general public could be subjected.

Dr. Gardner did not think that people should worry about the widespread use of asbestos in homes and other buildings. It did not present a gross risk in real terms.

MR. GRANT said that asbestos in homes and similar situations was dangerous in the same way that the gas or electricity supply could be dangerous, and should be treated with the same respect.

People would act to prevent their children sticking knitting needles into electric sockets, and would not remove panels marked "Danger, live electricity supply". They should be encouraged to have the same attitude towards asbestos. It should be sealed and made safe and children should be cautioned not to drill holes in it and the rest of the family should be warned not to sand it down with portable tools.

Even where the material suffered accidental damage, Mr. Grant still thought there was no reason to panic. If a material was asbestos cement, very little fibre would be released anyway. Also, once again the aspect of time weighted exposure was important. The odd incident of that type of exposure led to what could only be called a negligible risk. It was less than the risk of being struck by lightning.

MR. ALCOCK said that in the survey that Manchester had conducted of warm air heating systems, no release of fibres had been found. The only point he had wished to make was that if asbestos in that situation was damaged (and it would usually be damaged during maintenance) then, because it was an air system, the fibres would become airborne.

MR. B.P. HANNA (Belfast City Council) said that the "public perception of environmental problems" had first been raised by Dr. Holdgate on the Tuesday morning, and in his view had been the principal theme of the Conference all week. The discussion that morning had highlighted the problems arising from the public's perception of the risk associated with asbestos and their mistrust of official or expert statements. Mr. Hanna agreed with Mr. Alcock that public perception of the asbestos problem had been shaped by the media, but he disagreed with Mr. Alcock's view that leaflets could be used to redress the balance and counteract the effect of highly sophisticated media techniques. Leaflets had their uses, particularly as reference material which could reinforce or state a few facts. However, Mr. Hanna's experience was that it was almost impossible to counter views put forward by the media using such simple means. Dr. Gardner had said that the media should be educated, but Mr. Hanna felt that it was impossible to educate the media until one thoroughly understood the way that media people worked, and the pressures on them.

In Mr. Hanna's view, it was too simple to blame the media for presenting the issues badly. Most people would agree that many interesting and informative programmes appeared on television, for example, and in the case of asbestos, it might be that the experts or professionals had failed to get their message across to the media, rather than the failure being on the media's part. Mr. Hanna considered it most important that environmental health officers should be trained to deal with the media. His own authority had run an excellent course, which had given him a clear understanding of the way the media worked - something he had lacked until then. He now knew that it was important to respond quickly to any item of news or a press article with which one disagreed. It was also important to comment when asked, and give the facts clearly. People had to believe in what they had to say, have the courage to say it, and say it in such a way that the message was clear to the man in the street.

DR. GARDNER said that he agreed with Mr. Hanna's comment on the need to understand the media. At press conferences he also tried to ensure that he responded properly and clearly to questions, and was always willing to check journalists' copy before it was published, if asked to do so. A two way exchange of information was necessary in order to improve the way facts were presented in the press, on television and on the radio.

MR. GRANT thoroughly agreed with those sentiments.

MR. ALCOCK made it clear that he did not believe that leaflets could counteract media coverage of an issue. In fact, he thought it would be extremely unhealthy if they could, since the first move of any burgeoning dictatorship was always to sieze control of the media! Thus, his aim was not so much to counteract the media, but to use its power to present the truth as far as it was known - to give a balanced view.

The great value of leaflets lay in the fact that they could be used as a reference source. Members of the public could keep the leaflet, and when they had a problem they could consult the leaflet for advice, or for the name and address of useful contacts.

COUNCILLOR A. HOME (Manchester City Council) asked Mr. Grant how on earth it was possible to insulate asbestos in a ceiling that was being taken down.

Secondly, he said that young men such as Phillip Alcock were more valuable to the city of Manchester than Brian Robson; he just hoped that the EHO would not demand the same wages!

COUNCILLOR LEWIS HERBERT (Greater London Council) said that as Chairman of the GLC's Environmental Panel, he took a particular interest in asbestos matters. He agreed with the view that both councillors and officers played the part of "pig in the middle" in relation to the current concern about asbestos.

Referring to the earlier question by Cllr. Cooper from Walsall, Cllr. Herbert said that he personally was not totally easy in his mind about the removal and disposal of asbestos, certainly as he had seen it carried out in the London area.

He asked the speakers what they saw as the priorities for government, and what leadership they considered that central government should give to local authorities facing the current range of problems with asbestos.

MR. ALCOCK considered that central government should show far greater commitment to dealing with the problem. At a time when local government resources were being so tightly squeezed, central government had to show its commitment to tackling asbestos by providing the necessary resources in terms of finance, manpower and equipment.

As far as leadership was concerned, he considered that the only leadership local authorities needed was from their own citizens. They did not require central government to take the lead.

MR. GRANT wished to point out that the amendment slip issued at his request during the conference and which amended figure 3 of his paper, was still incorrect. He said that the word "crocidolite" in the key should read "chrysotile".

Referring to Councillor Home's question, Mr. Grant said that it puzzled him somewhat. Removal of a ceiling, and asbestos insulation, were quite separate things. The taking down of the ceiling which involved loose asbestos insulation material was a form of demolition and required a licensed contractor to do the job. In his earlier remarks, he had meant to indicate that where it was known that there was asbestos material behind a ceiling, the first option was to seal it in, lining it from above and below.

On the subject of government help and advice, Mr. Grant said he would make no comment on the provision of funds to local authorities, but would draw attention to the very sensible guidance given by the Department of the Environment publication "Asbestos in Buildings". He assumed that most of those present would know about the pamphlet and already possess a copy. Section 5 of the booklet gave the same advice as he and other speakers had given that day.

M.J. GARDNER

TABLE 2

REPORTED LEVELS OF ASBESTOS CONCENTRATION OUTSIDE WORKPLACE

Location	Nanograms per m^3	Fibres per ml	Proportion of "standard" (0.5 fibres/ml)
Inside buildings (median level)	-	0.005	0.01
Outside buildings (highest levels)			
Factory grounds	10	-	0.0004
Factory Town Centre	10	-	0.0004
Industrial site	10	-	0.0004

(Amendment to Table 2 on page 6 of the paper by Dr. M.J. Gardner)

SESSION SEVEN

WASTE DISPOSAL

THE ROLE OF THE HAZARDOUS WASTE INSPECTORATE

D.A. Mills, Chief Inspector Hazardous Wastes,
Department of the Environment

RADIOACTIVE WASTES

Marion D. Hill, National Radiological Protection Board

MR. D. BIRD (NSCA, Yorkshire and Humberside Division and Sheffield City Council), opening the discussion, said that the whole Conference had been of an excellent standard and that the quality of the papers presented by the last two speakers had reflected the high standard of all presentations. He wished to congratulate both the speakers and the Society.

Reminding the audience that Sheffield was a nuclear-free zone, Mr. Bird said that this did not mean that he was necessarily against nuclear power.

Referring to Mr. Mills' presentation, Mr. Bird said that he was most encouraged to see that the Hazardous Waste Inspectorate was actively involved with consultations on the concept of best practicable environmental option (bpeo). Commenting that the Inspectorate would need to consult very widely if it were to fulfill its brief on the use of bpeo, Mr. Bird suggested that water authorities should be added to the consultation list.

Mentioning that Sheffield had a large-scale problem with contaminated land, Mr. Bird said that this was a legacy of past, inadequate, disposal policies. He considered that, were the mistakes of the past to be avoided, the current licensing system should be placed within a tighter framework of control than that which existed. In that statement, there were implications for resources and manpower, and he wondered whether the small advisory Inspectorate was, in fact, adequate for the task. The final statement in Mr. Mills' paper had caused him some concern, since in his view it implied that the Inspectorate was torn between various priorities, in exactly the same way as other Government Departments. Mr. Bird considered that all departments, and particularly those within DOE, had to come to terms with the fact that if they were not to enlarge, they had to restrict their attention to the most important tasks. They could not be all things to all men.

Turning to Marion Hill's paper, Mr. Bird said he had found in it an excellent balance. He personally had his worries about nuclear power, but said that he could not sensibly comment on decisions that had not yet been taken about the future development of Sellafield or the nuclear industry in the UK. Nevertheless, he fully endorsed the comments made by the Royal Commission on Environmental Pollution (in their 10th Report) on secrecy. He considered that the nuclear industry had fallen into the trap of being too secretive and he warned the hazardous wastes industry not to follow the same course. As the RCEP had said, secrecy fuels fear. It fuelled fear in professionals and in non-professionals alike. The job of civil servants, of inspectorates etc. was to serve the public and provide them with as much information as possible.

Mr. Bird said that he had been appalled by the television programme on the NIREX proposals. In his opinion, NIREX had to accept that it was a public body, and that it therefore had to be open in its dealings. He wondered if Marion Hill would comment on that point.

He considered that the recent public concern about radioactive waste, the transport of waste, and the secrecy that surrounded it, did nobody any good. For example, it had later emerged that the recent much-publicised shipwreck involving containers of radioactive wastes had resulted in a release to the sea which was no greater than the radioactive emissions that he would get from his own wrist watch. The public concern had arisen because people simply did not have enough information about the radioactive waste that had been on board the ship. That concern had been heightened by statements that the ship would have returned with a more hazardous cargo. He asked both speakers if they would help to ensure that their respective organisations operated more openly in the future.

Finally, Mr. Bird said somewhat wryly that he regarded it as regrettable that people in the Sellafield area could no longer eat winkles. He wondered how long it would be before people in Brighton would be unable to eat oysters.

MR. D.A. MILLS said that if his paper had failed to mention water authorities under the list of those consulted in connection with bpeo, he could only apologise. In fact, as resources permitted, the Inspectorate was attempting to liaise with all interested bodies including the regional water authorities.

On the basis of the first year's work of the Inspectorate, Mr. Mills said in response to Mr. Bird that a tighter framework of controls over some aspects of hazardous waste management might prove to be necessary. Elaborating slightly on the question of resources, Mr. Mills said that he had always firmly believed that the control of hazardous waste disposal sites depended principally upon fieldwork, inspecting and policing the situation on site. In some cases he considered that more resources might be required, and in others, it might be a question of redeployment of existing resources.

On the question of secrecy, Mr. Mills said that he basically agreed with Mr. Bird. His belief, and that of the Inspectorate, was that the facts should be published, and the debate should centre on the interpretation of the facts rather than the presence or absence of the facts themselves.

Turning briefly to the question of hazardous cargoes, which was relevant to hazardous wastes as well as to radioactive wastes, Mr. Mills said that it was no secret that there was an international trade in hazardous wastes. Loads which entered or left the UK were governed by transport regulations brought in by the Health and Safety Executive, and also by Community law - The Transfrontier Directive, as well as being subject to UK waste management legislation.

MS. M.D. HILL said that in general she agreed with Mr. Bird that the nuclear industry in the UK tended not to provide sufficient information about its activities. Too often, it provided propaganda rather than information. She herself tried hard to persuade people in the nuclear industry to put forward more information, including detailed technical information where necessary. She thought this far preferable to making simplistic statements and attempting to give simple reassurances.

She believed that she could detect some improvement in the industry of late. NIREX, for example, had tried to supply the public with information in relation to their proposals. There were some questions which they simply could not answer. For example, people frequently asked NIREX which wastes they would put in particular sites. That question could not be answered until a detailed site investigation and risk assessment had been carried out. Thus, it was not always an engrained habit of secrecy which prevented a response to public requests for more details, but simply lack of information at the particular time. However, on other questions the industry and authorities could perhaps be more open. For example, NIREX could reveal which sites had been examined.

NRPB tried to publish details of all their work. That was NRPB policy, and as a result they issued many reports. She hoped that NRPB was not considered in the same light as the nuclear industry, i.e. not regarded as secretive.

On the transport of radioactive materials, Marion Hill said that it had to be remembered that there were many small shipments of radioactive materials all around the globe every day. Isotopes were produced in one country and sold to another country for research purposes. That type of material was transported all the time, and any system which attempted to notify each and every shipment would produce vast masses of useless paper. Some line had to be drawn, and that was the reason for the non-notification of the cargo in the Mont Louis. The cargo was known to be radioactive when it was loaded, but there was no normal system of announcing or notifying that fact.

Referring finally to the Cumbrian winkle eaters, Marion Hill said that people who were high consumers of winkles close to Sellafield were receiving doses equivalent to about half of the ICRP dose limit. By the end of 1984/beginning of 1985 the discharges of alpha-emitting particles from Sellafield would be reduced so that the dose to such people would go down. British Nuclear Fuels had also announced plans for the investigation of ways and means of reducing the discharges to a level that was as low as they could manage, in which case the doses would be reduced still further.

In summary, Ms. Hill said that people could eat winkles from Sellafield; the dose they would receive would be comparable to that obtained from the natural background, but people could choose not to take that order of risk.

CLLR. LEWIS HERBERT (Greater London Council) said that one of his major tasks, since his election as the GLC's Chairman of the Environment Panel, had been to tighten up the controls on waste sites. While London did not have many disposal sites, it had a great many transfer sites. In his experience, the "cat and mouse game" of using licensing conditions was a very difficult one. The system of appeals to the Department of the Environment had made the whole procedure much more difficult. It was all very well for local authorities to be required to act as policemen but unless they were actually given proper powers they could not be expected to enforce the law. He asked for Mr. Mills' comments.

Where adequate facilities for waste disposal had been in existence, some, such as the incinerator plant for hazardous waste at Rainham, had been closed down by the district council's planning department. Although the GLC had a strategy for the disposal of hazardous wastes, it had never had the planning powers to carry through its proposals properly.

His real concern was that if David Mills was not, in his role as Chief Inspector of Hazardous Wastes, a policeman, then the local authorities with their lack of powers could not be expected to fill that role. He wondered who in fact was to enforce the legislation.

Saying that he believed the "not in my backyard" syndrome to be stronger amongst the district or borough authorities than amongst the county authorities, Cllr. Herbert asked Dr. Mills whether he could say which authorities he considered to be most effective in the disposal of hazardous waste - the metropolitan counties or the rural counties - bearing in mind that the Government had announced its intentions to abolish six out of ten authorities which handled the majority of hazardous wastes produced and disposed of. He wondered if Mr. Mills had any comments on the proper disposal of hazardous wastes in the future, should the Government plans go through.

MR. MILLS said that he assumed Cllr. Herbert's point about the difficulties of the appeals procedure was specifically concerned with the amount of time that it took for the Department of the Environment to process appeals. He said that since its inception, the UK's waste management strategy had always been one of devolved executive powers, ie. to the waste disposal authorities and that they were the enforcement agencies. In contrast, under the Radioactive Substances Act 1960, control was vested in a central authority, and Mr. Mills wondered whether perhaps Cllr. Herbert saw that as a preferable model for the management of hazardous wastes. That is, that there should be a central body responsible for issuing authorisation for disposals. Mr. Mills said that, up to a point, he shared that view himself.

Saying that the major task of the new Inspectorate, which he headed, was the achievement of better and more uniform standards nationally, Mr. Mills said that his job would, of course, become much simpler were controls to be centralised. A "National Waste Disposal Co. Ltd." for example, would ensure the more rapid application of uniform standards. However, he did not consider that such a solution would be widely acceptable.

As to the demise of the Rainham incinerator, Mr. Mills said that there had been a much more recent example in the closure of the ReChem plant at Bonnybridge recently closed for commercial reasons.

Mr. Mills said that he was not convinced that the private sector in hazardous waste management was in fact vulnerable. He believed that they had, in the past, done their sums very poorly: ten years previously, for example, there had been ten separate plants for the incineration of hazardous waste, whereas there were now only four which coped with the whole market.

Referring to the future of hazardous waste management in the light of the Government's proposal to abolish the Metropolitan Counties, Mr. Mills said that it could make life more complicated. However, reminding delegates once again that the Inspectorate's function was to work towards greater uniformity of standards, he stressed that obviously the requirement to demonstrate satisfactory co-operation between the new authorities was important here; since any move that at a stroke created 69 extra waste disposal authorities, 69 additional licensing authorities (which meant that 69 additional waste disposal plans would have to be submitted), was bound to create great difficulties for the Inspectorate. At the end of the year, the Inspectorate had to report to Parliament, and the proposed abolition of the Metropolitan authorities, and the implications of that move, would have to be discussed in that report. He could not at that point speculate as to what would be said in the report - he was not in a position to make any definitive statement in any case, since the Inspectorate had not finished visiting all the Metropolitan authorities. Indeed, he had yet to visit the Greater London Council. All he could say was that first impressions suggested that some of the more rural shire authorities were perhaps less professional in their approach than the most industrialised areas represented by some of the Metropolitan authorities.

CLLR. R. KIDD (Newtownabbey B.C.) expressed appreciation for the way in which the speakers had responded to questions, and their honesty in saying so when they did not know the answer to a particular point! He also expressed approval for the subjects covered at Conference, and the broadening of the range of topics in 1984.

Referring to hazardous wastes, Cllr. Kidd recalled an occasion in which he had been working with reclaimed land which had been covered with earth on top of which were concrete piles. The excavations had been necessary in connection with laying drains to connect with the sewers. The waste consisted of poisons and medicines from a wholesale veterinary surgeons' supplier. It was a fortunate coincidence that Mr. Kidd had been on the spot to identify the material, which he could do since he had been involved with the relocation of the wholesale suppliers' premises. The material had been removed under the supervision of a public health inspector, and had been carted off in a lorry for disposal under the same supervision. That incident led him to wonder what precautions should be taken when rebuilding or excavation was taking place on contaminated land, or land which had hazardous waste buried on it.

His second question was to Marion Hill and concerned the public's faith in the pronouncements made by scientists. Cllr. Kidd said that this faith had been shaken recently by the conflicting statements about the safety of operations at Windscale (Sellafield). He asked her what scientists and the Government could do to restore the public's faith in pronouncements from official sources about the safety of nuclear installations.

MR. MILLS said that he was not sure that absolute guarantees could be provided in relation to the after use of landfilled sites which had been used for the disposal of hazardous waste. Restrictive planning conditions could be placed on the after - use of the site as part of the consent, and could for example require that it be restored afterwards for use as agricultural land or as a recreation site. In the short term such solutions were viable, but no-one could be sure what would happen to the site in, say, 50 years' time.

In answer to the specific question on the burial of the poisons and medicine, Mr. Mills said there were two or three ways in which such an occurrence could be avoided for the future. The first was to destroy the medicines by some alternative process, i.e. by incineration or even maceration. One of the objections he himself had to the landfilling of old medicines was that they were invariably extremely well packaged with perhaps three layers of packaging - blister pack, shrink wrapping, cardboard box and finally the outer crate - which meant that they would still be intact after a decade or so. Another answer would be to macerate the materials before landfill. The third and most obvious solution was to ensure that (where they simply had to go to land) they were consigned to a sufficient depth on a part of the site that would be finished at a sufficient height to make it highly unlikely that (even with excavation work for sewerage) they would be disturbed.

MS. HILL said that really nothing could be done to bring back faith in scientists. She felt that to regard scientists as the arbiters of truth was somewhat old fashioned. What scientists could do was to provide as much information as possible about a particular subject, but at the end of the day some sort of value judgement would have to be made. That was true in particular of nuclear matters and indeed of any subject in which the words "hazardous" or "safe" appeared. Those were relative terms, so that scientists could not meaningfully say that something was not hazardous or not safe. All they could do was to explain what were the risks in terms of numbers. They could not direct what use should be made of the numbers or what interpretation should be put upon them. That was the position in many other areas apart from the nuclear industry. It was simply part of the evolution of society that scientists and science impinged more on people's everyday lives.

MR. T. JONES (Torfaen B.C.) asked Mr. Mills just how public the report he was preparing for presentation to Parliament at the end of the year would be. He wondered whether the report would be restricted to Parliament and to the Department of the Environment or whether it would be open to the scrutiny of all interested parties and pressure groups.

Mr. Jones asked Ms. Hill whether the disposal of very low level radioactive material could be accomplished by incineration at very high temperatures.

Turning again to Mr. Mills' paper, Mr. Jones took issue with him on the UK's strategy for waste management. He said that there was currently a ridiculous situation: tankers loaded with hazardous waste material left Wales bound for disposal sites in other parts of the UK, while along the road in the opposite direction would come a tanker full of waste from somewhere in England bound for the ReChem plant in his area! A proper strategy had to be worked out which would prevent dangerous material being transported long distances along roads in the UK, and enable it to be disposed of at sites near to its point of arising.

MR. MILLS said that the report of the Hazardous Wastes Inspectorate would be publicly available.

Referring to the overall strategy for hazardous waste management in the UK, Mr. Mills said that England produced approximately 4 million tonnes per annum of hazardous waste and Wales's output was one tenth of that, at about 400,000 tonnes. In the current financial year so far, ReChem's plant at Pontypool had dealt with some 16,000 tonnes of waste. That left a great deal of Welsh hazardous waste to be disposed of elsewhere; a very small proportion of that went to landfill in Wales and the majority was sent to England. Of the 16,000 tonnes handled by ReChem in Wales (and that amount related not just to incinerated waste but to chemically processed waste), the largest regional contributors were Wales and south west England. Some of the waste did come from England, but he thought it highly unlikely that incinerable waste from Wales travelled to Bonnybridge or Fawley or Nottinghamshire. Some waste from North Wales might be sent to Ellesmere Port, because that would, in geographical terms, be the nearest incineration plant. The major hazardous waste producing areas in England and Wales were also the major disposal areas, and only a minority of waste was transported long distances for disposal.

MS. HILL said that quite a lot of low level radioactive waste was incinerated, with many power stations having their own incinerators for that purpose. The residual ash was radioactive, and the filters which had to be fitted to the chimney stack also had to be carefully disposed of. In general, incineration was a very useful method of reducing the volume of low level waste, and as such, was widely used.

CLLR. L. HARRISON (Wakefield M.B.C.) reminded the speakers and various participants in the Conference debate that, at the end of the day, it was the politicians in the audience who would take decisions affecting expenditure on environmental controls at local level. Since most of the politicians were laymen, they required information to be presented clearly in intelligible terms that could be readily understood and used by Councillors in making their case on the subject in the Council chamber. He was grateful to Marion Hill for the clear terms in which she had set out the issues relating to the disposal of nuclear waste.

From his perspective as a representative in a coal mining area, involved in an industry which produced millions of tonnes of waste a year and which had a long history of work-related disease and disability and death, Cllr. Harrison wondered whether people really knew how to balance the risks associated with new developments, in say the nuclear industry, against the benefits it brought.

MS. HILL said that throughout the short history of the nuclear industry, a great deal of care had been taken to keep the risks low and indeed more money may have been spent on doing that than was really warranted.

As far as waste disposal in particular was concerned, a fair amount of money had been spent on that aspect, and until now people's exposure as a result had been very low. However, very little waste had actually been finally disposed of. It was all stored to be disposed of at some point in the future. The current trend in standards meant that the risk to people of future generations would be as low as possible. In the UK, some £10-12 million per annum was being spent in examining the problems of waste disposal, and in trying to provide the information on which the best all round options could be decided upon.

Some people felt that that money would be best spent on solving today's problems, e.g. in reducing what were currently the highest exposures. But the research was being undertaken because of public perception about the long-term risks of radioactivity and of the waste.

MR. MILLS said that while nowhere near the amount of £12 million was being spent on research into the disposal of hazardous waste, much research was being done, and standards were improving. As to what sort of cost people should be prepared to accept in order to enjoy the fruits of modern technology, Mr. Mills said that certainly everybody enjoyed driving motor cars, or watching television, and the manufacture of both those consumer desirables produced hazardous waste, some of which was extremely unpleasant. That, however, was only a partial answer. Another factor was that some methods of disposal were cheaper than others. If all the waste produced during the manufacture of a television had to be treated by unnecessarily highly sophisticated encapsulation, long-term storage methods, it would add a significant amount to the price of the TV.

Mr. Mills said that amongst the vociferous views expressed during the recent intense public debate about the disposal of hazardous wastes, one school of thought was that those wastes should not be disposed of to landfill, and another, that they should not be incinerated. Between the two, Mr. Mills could not quite see how it would be possible ever to dispose of hazardous waste. The wastes existed, and had to be dealt with in a responsible and environmentally acceptable fashion.

MR. J.J. BEAGLE (NSCA, London and SE Division) said that he believed that the UK was the only country in the world that permitted nuclear waste to be discharged into the sea from various installations. In view of the recent incident at Sellafield, he asked the reasons for the UK's policy, and whether it was the best practicable environmental option.

MS. HILL said that the UK was not the only country to have this practice. Every country with a nuclear power programme discharged wastes into the sea. Indeed, every country which used radioactive material, for example in medical research, also discharged radioactive waste into the sea. In some cases it might enter a river or stream first, but eventually it would reach the sea.

Regarding the situation at Sellafield, Ms. Hill said that it was not considered practicable to ban all discharges to the sea. However, the level of these had been reduced and thus more material was being stockpiled on site for eventual disposal, presumably to land. The choice that everyone faced when they built a nuclear plant was between discharge or land disposal. The preferred option depended very much on the particular site and the position of the discharge points. For example, if the site was on a river bank, very little would be discharged to the water course, principally because it had a very long way to go before reaching the sea. Many people might take in radioactivity along the way. Power plants on the coast, where more immediate dispersion and dilution was possible, could afford larger discharges.

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51st ANNUAL CONFERENCE
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AIR POLLUTION CONTROL – THE GLOBAL DIMENSION

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The topic I have been invited to address is all embracing and has the potential to become more significant with time, due to the increase in world population and the goal of third world countries to achieve similar standards to the developed nations - meaning that there will be increasing energy use per capita in those areas. Thus, on a global basis the potential for air pollution will increase. It is up to people in Societies such as our own to ensure that the world will survive under such conditions.

I will confine my comments to three aspects of global air pollution, namely

1) acid rain water
2) the influence of CO2 on the atmosphere.
3) the problems, as I see them, in the less developed countries, particularly those neighbouring Australia.

People in Europe are far more familiar with acidic rainwater (more commonly known as acid rain) than we are in Australia. In the Northern hemisphere, acid rain has achieved a public, emotive significance which probably outweighs its real effects.

The industrial causes of acid rain are fairly well known. But, as I see it, in Europe so far only industrial sulphur seems to be singled out for control, whilst non sulphur and natural causes are by and large ignored. In fact, man's activities contribute only $\frac{1}{4}$ to $\frac{1}{3}$ of total sulphur emitted to atmosphere; the problem is that this emission is concentrated in specific locations, so that it affects those and surrounding areas. The effects of acid rainwater are not nearly so well understood as they should be, but unfortunately it is receiving the blame whenever flora and fauna are observed to be affected, whether it contributes or not.

To help explain the situation and my remarks, I will share with you some findings and observations from my own country. Australia is a unique monitoring station: it is situated in isolation and it consumes non-to low-sulphur fuels. Sydney, specifically, is a city with a population of about three million, and with an annual fuel usage of about 7 million tonnes of black coal equivalent, divided as follows:

Fuel	% of total fuel used	Sulphur Content
Natural Gas	28	negligible
Coal	4	0.5%
Fuel Oil	1	1% (by regulation)
LPG	2	neg.
Distillate	14	0.1%
Petrol	51	0.1%

Sydney itself is a city in isolation, not under the influence of other industrial centres, and monitoring for acid rainwater has yielded pH values down to 3.6, not severe by your standards but nevertheless significant from a non sulphur emitting city. We have also observed that conversion occurs over a time span ranging from seconds to hours (in other words, the effect is felt directly in the city itself) and that conversion rates vary significantly between day and night. Obviously NOx is the significant source and vehicles the major contributor; we have no continuously operating power stations within this particular area.

As an aside I should also add that although air monitoring has not embraced the whole continent, we have measured pH values down to 3, right in the centre of the Northern Territory in a remote region hundreds of miles from any industry or vehicles. On analysis, it was found that the main contributor was formic acid, and the acid surge occurred at the beginning of the wet season. We do not know the source, but we know that fish in the water holes died. Investigation showed that this was due to minerals in the soil rather than acidic rainwater.

Thus, we in Australia have had the same problems that have been experienced in the Northern hemisphere, but none of the causes that are presently being controlled for in Europe and US. Perhaps I should also tell you that some of our forests are dying - not just affected (as I, an untrained observer, failed to see when motoring in the forests of Southern Germany last month). We are losing forests in the South Western part of Western Australia, and in the Central New England area of New South Wales. We suspect that the causes may be agricultural, or due to bauxite mining, but we haven't identified any positive link as yet.

Another example is from my own home town of Manly. Our ancestors planted Norfolk Pines along Manly Beach over 100 years ago. About 15 - 20 years ago, these started to die along the northern end of the beach. It took us about a decade to determine the cause, which proved eventually to be detergents coming from the effluent outflow 2 or 3 miles to the south. The detergents entered the seawater, and in a south easterly wind were caught as an aerosol and deposited on the waxy fronds of the pine trees. Over a period of time, this caused the trees to die. Now, $\frac{1}{3}$ of the pines along Manly Beach are dead and cut down. We are now extending the outfall by some two miles, but the job will not be completed until about 1990, and it is far too late to save the trees already dead!

The point of all this is to draw attention to the fact that acid rain (or at least, the effects associated with acid rain) is not a phenomenon peculiar to the Northern hemisphere. The effects are not caused solely by sulphur in fuel and industry, and flora and fauna are affected by factors other than acid rain.

However, I'm not trying to absolve sulphur, since obviously it is a contributor and needs to be controlled, but I am concerned by the nature of the controls being enacted since they may be counter-productive. Is the

FRG merely following the US EPA in requiring both an emission limit plus a percentage (9%) reduction? I am unsure of the original reasoning behind the US decision, although I suspect it was aimed at protecting high sulphur eastern US coal, by requiring the installation of back-end cleaning on power plants.

This has proved counter-productive, since while US industry fits sulphur control equipment, it is not necessarily able to make the equipment operate at its design efficiency at all times. Thus emissions occur. My view is that an incentive should be given for the use by industry of low sulphur fuel.

Further, I believe that motor vehicle controls must be effected in Europe if Europe is to come to grips with the problem. Sulphur control is just one side of the coin. You have to face up to the other contributing factors. In the light of present technology, I believe that lead free petrol, and the installation of catalytic convertors on all new vehicles, is the most significant step that Europe can take to control the source of both acidity and oxidants. We in Australia have set 1 January 1986 as our target date for these measures; I suggest Europe should also act quickly to come to grips with reality, and should set its date. Motor vehicle manufacturers can adapt and oil refiners can produce lead free gasoline - judging by the US and our experience, at an affordable cost.

The second area that I wish to address concerns the increasing emission of CO2 resulting from the combustion of fossil fuel, and its long term effect, the potential to induce climatic change.

I believe that there is no alternative to the continuing and expanding use of fossil fuel to supply the world's energy needs. Hydro, solar, wind, tidal and other renewable energy sources can only be used for a minor percentage of the world's needs. The remainder will be supplied by fossil fuels and nuclear energy, with fossil fuels supplying the greater proportion for the foreseeable future.

This means that CO2 emissions will increase; therefore it is important to understand the long-term effect.

Monitoring carried out at Cape Grim, North West Tasmania, sampling "the cleanest air in the world", showed an increase in CO2 concentration, from 1972 - 1982, of 4% - from about 327 ppm by volume.

The world's increase, using a one-dimensional model, shows that since pre-industrialisation there has been an increase from about 260 ppmv in 1800 to 340 ppmv in 1980. The model was based in the Northern hemisphere, where the situation is a little worse.

The prediction models that exist (and these are quite imperfect) estimate that for a doubling in CO2 levels which we anticipate in the next century, we may expect an average 2°C temperature rise. However, the models are imperfect; based on the experience of the past 150 years, during which we know there has been an increase of approximately 30% in CO2 levels, we have seen no atmospheric temperature rise. This is heartening; it also means that factors exist which have not been included in the models, so their ability to predict accurately is suspect. For that reason I suggest that this area should continue to be researched at a sufficient level (and this involves government funding) to produce reliable predictions by the end of the next decade. After all, if we are facing major changes, we need real knowledge on which to develop major planning on a global basis.

The third, and to my mind the most important area I wish to discuss, is the lack of air pollution control in many developing and Third World countries.

Understandably, the governments of these countries, although supporting environmental controls, give their priority to jobs and development aimed at improving GNP, in traditionally poor communities.

There exists a conflict of interests - money spent on pollution control is seen as money that could be spent on production or development.

However, many of these countries are now faced with enormous pollution problems, resulting from development without control. I have experienced these problems personally, and found them intolerable to live with and damaging to world heritage treasures.

In some countries, lip service is paid to pollution control, but unfortunately it is not practised: to the extent that one can get soiled with black grime when driving around in Manilla! In fact, I have personally experienced throat and chest problems for several days following exposure to extreme traffic congestion in this city. That was gross pollution - with the sensation that one simply could not breathe. For those living in these countries and suffering such conditions on a daily basis, the effects on health must surely be very severe.

I was also appalled, when travelling on a Government mission to Mediterranean countries last year, by the damage air pollution has caused to the world's cultural heritage, to statuary that can never be replaced. The faces of the images are simply dissolving. To quote just one example, in Cairo it is now impossible to see the Sphinx or the Pyramids if you are staying in hotels along the Nile. Yet, once that view was world famous.

These problems are real and need to be solved, and the governments of the richer, developed countries can help.

Most of the countries so severely affected by air pollution have another thing in common: they receive aid from the governments and banking institutions of developed countries. I believe that these bodies should encourage, or better still direct, that part of this aid should be for pollution control.

I shall, in conclusion, summarise the theme of my address in four points:

1. In the Northern hemisphere governments should come to grips with the problem of acid rain, and should adopt a statesmanlike approach to enacting legislation aimed at controlling emissions contributing to the problem.

2. Monies should be directed by governments into research into the effects of acid rain, so that the blame can be apportioned as it is deserved. There should also be continued research, at the level that is necessary, into the consequences of increased CO2 emissions.

3. Governments and world monetary funding bodies should direct that funded programmes for developing countries should incorporate specific monies for environmental controls, while the assisted governments should be encouraged to take effective measures to ensure that control occurs.

4. Technical bodies, such as those who are members of IUAPPA, together with IUAPPA itself, should bring these matters to the attention of their governments for appropriate actions.

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EUROPEAN OBJECTIVES AND INITIATIVES

By

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The question of clean and unpolluted air has been with us for a very long time, but in recent years there have been one or two developments in the United Kingdom which I think have helped change our perspective. First, it is now recognised that the matter is not something that can be dealt with simply at national level; it has become clear that while there is a valuable and important national perspective the problems are international in nature and international solutions must therefore be sought.

Secondly, I think there has been a re-assessment of the environment as a political issue. This is true in the United Kingdom and even more true on the Continent. The recent news, for example, of the local elections in North Rhine Westphalia indicates very clearly the relationship between environment and the mainstream political thinking in Germany.

Thirdly, in 1973 we joined the European Community. I concede that there are many people who are doubtful about whether we should have joined but I do not intend to engage in that argument here today. The point is that membership of the Community has focused the attention of people in Britain on the activities of the Green political parties in Europe and at the same time it has compelled us to take note of the international perspective developing in this area. My intention, therefore, is to examine very briefly the role of the European Community and of the Parliament in particular in taking initiatives in the field of clean air. I want to discuss some of the problems that arise in this process and I want to indicate where I think we ought to be going at the moment.

The international nature of the air pollution problem - the acid rain problem if you like - is no longer seriously contested and solutions are being sought at international level. I want to make a particular point about the European Community's involvement. Although there are many organisations at international level involved in the acid deposition debate - OECD, the United Nations etc - the European Community has one unique feature and it is that it combines the international scale with the power to legislate. That marks it as being quite separate from the other organisations that are involved. Here is a body of ten nation states who are able to introduce legislation and to make that legislation stick. I concede that there are only ten countries, nonetheless, the European Community, because of its economic dominance in Europe and because of its political strength, has a wider sphere of influence than appears at first sight and therefore any action by the Community in a field such as this is very important indeed.

Action by the Community is very difficult to get to grips with, partly because of the complexity of its institutional arrangements. There are few people who understand completely how the European Community works and many otherwise politically aware individuals are singularly ignorant on the point. So, while it is not my intention to describe in detail exactly how the European Community conducts its affairs, I do believe it is necessary to give a very brief outline.

In the first place, the Commission can probably best be seen as a Civil Service on the one hand and initiator of ideas on the other: the engine for progress in the Community. (Some of us have doubts about how much steam is left in the engine these days but nonetheless it is supposed to be the engine for progress and the initiator of ideas as well as the Civil Service of the Community.) The European Parliament is a very peculiar organisation: it is not all that it might be, but nonetheless it is best understood as critic of the Community, assessor of the Community and initiator of ideas. Then there is the Council of Ministers. This is probably the most misunderstood institution of them all because it tends to be thought of in this country as something distant and unrelated. Well, it is not, and in the case of environment policy the Council of Ministers consists of one Environment

Minister from each of the ten member states, so Britain is always represented. The Council can be best seen as occasional initiator, final executive of the Community - and probably its principal stumbling block.

In the case of acid deposition, all three of these institutions have been involved in taking the initiative. The Community as a whole is a signatory to the Geneva Convention on Long-range Transboundary Air Pollution and research has been undertaken, for example at ISPRA. A Community data base is being established and new legislation is coming forward but there are three particular events that I would like to note.

The first is the Stuttgart Summit of June 1983, when the Heads of State or Government emphasised the importance of action to combat acid deposition which was identified as a priority concern. Thus we had the authority of the top layer, if you like, of the European Community committing itself to action in this area. Then the Commission held an important symposium in September 1983 on acid deposition in Karlsruhe which attracted a great many people from all over the world: a very useful exercise I think. Even before this the European Parliament's Committee on Environment, Public Health and Consumer Protection held a public hearing on the subject in March 1983. I should like you to note the sequence of dates. The European Parliament hearing was in March, the Council summit in June and the Commission was in September. I merely make the point that the European Parliament was in advance of the others.

The problems of European Community action derive in the main from the complexity of procedure and uncertainty about power relations inside the Community. When the Commission does decide to do something about anything at all, in this case acid deposition or air pollution, it does consult fairly widely. It consults national experts, all kinds of people, but its consultation is very, very opaque to say the least. The consultation process is lengthy, but it is never very clear whom they consult, or when, or in what order. Only very rarely at the end of it all does the Commission publish a list of whom they have consulted. This is something that I have been discussing with them for a very long time and we have had the occasional breakthrough, but we have also had the breakthrough followed by relapse into former practice.

When the Commission finally reach their conclusions and publish their proposals for legislation, the proposals are then sent to the European Parliament. Here the problem is that the Parliament is a relatively new institution in its present form. It has only been there since 1979 and I am afraid it is something of a clumsy fledgling of an institution. Like many clumsy fledglings it has a habit of falling flat on its beak from time to time and there is no question at all that it does lack a killer punch. It lacks the possibility of delivering the goods. It can deliver opinions, but its very lack of direct power leads it sometimes to make statements which, if it were in power, it might not make. In other words, if it actually had to spend the money at the end then perhaps it would be a little more careful in its pronouncements.

Once Parliament has delivered its opinion, the draft legislation then goes on to the Council of Ministers for final decision. The problem with the Council of Ministers is that first of all nearly all of its work is conducted in absolute secrecy. We don't really know who has said what, or how the decisions were made. Also, there are national differences of approach, national differences of interest and of course there is a preoccupation with other areas of the Community's work. That is to say, over the last two or three years the Community has been dominated by the question of the budget and of agricultural policy, and in particular the British contribution to the budget. That has tended to detract from work in the environmental area, not because people are not well motivated, but simply because the

Community as a whole has been preoccupied with these very big issues which in the end could mean the continued existence or not of the Community as a whole.

National differences of approach, however, are also very important and the Department of the Environment officials will know more about this than I do. British legislation is full of expressions like "in normal circumstances" or "at the Ministers's discretion", but by and large in Germany they don't like the Secretary of State or the Minister having discretion, they like to have it pinned down very firmly. So there is a clear difference which comes through in nearly all the discussions at Parliamentary level and, I suspect, at Council level.

But there is always a point, nonetheless, when scientific advice gives way to political imperative. I have listened to many debates on the question of acid rain and acid deposition and I have listened to a great many people telling me that the time is not yet ripe for action because the research results are not complete and if we only wait another three or four or five years (it depends whom you listen to) then we will be in a different position. But there is very little doubt that the United Kingdom position in Europe, generally, is not widely admired. There was a letter in The Times recently which came not from a member of my party but from the Chairman of the Conservative Party Bow Group. I quote one phrase from it: "There is little doubt that the United Kingdom is widely seen as tamely trailing along at the back of the international pack and even to be obstructionist". These are not my words, these are not the words from somebody from the Labour Party Conference, these are the words of a Conservative Member of the House of Commons.

The idea that Britain is sometimes seen as the "dirty old man of Europe" is something that we have to be concerned about, all the more so since statements from some of our industrial organisations have simply become more and more defensive. Recent statements from the CBI,

for example, are full of gloom and doom - to the effect that if we do anything at all about acid rain it will be terribly expensive and British industry will never survive and lo, the end of the world is at hand.
The Central Electricity Board tells us time after time that the research results are not complete and that electricity costs will go up and that anyway acid rain has many more sources than major power stations, which of course is true. But then I remember that in the 19th century there were perhaps many sources of social evil but even the slave owners did not actually come along and say, "Look we are not the only people that are spreading gloom and despondency and nastiness and evil in the world, so why pick on us? We will stop enslaving people when somebody else has stopped sending little boys up chimneys".

My view is that since acid deposition is a multi-source problem you have to tackle each of the sources. The Community is tackling not just the question of major industrial plant but also the question of motor vehicle emissions. There is a constant stream of legislation emanating from Europe on the question of motor car engines and we do have a draft directive on nitrogen oxides at the moment and there is a move now to take lead out of petrol. The Labour Party, the Liberals and the SDP and the more internationally aware of the Conservatives are pressing the Government to take action now and I think that the recent Select Committee report from the House of Commons demonstrates the all-Party concern about this. The House of Lords' report on air pollution is also, I think, to be cited in support of a rather stronger approach than that being adopted by the Government at the moment.
As far as the Select Committee of the House of Commons is concerned, I certainly welcomed that report although, of course, I have to say (somewhat mischievously) that it is a shame that it only appeared a year and a half after the European Parliament's one!

On the assumption that there are still coal fired power stations by the end of the decade we do have one or two very important decisions to make in the near future. We have to decide whether to do anything at all or whether present evidence provides any basis for action. We have to decide whether to continue with present research studies or whether to accept the present level of evidence and legislate. I can't say that I have no doubts on this because I do have doubts. I think anybody in this field who claims that he has no doubts is either a fool or a knave, or perhaps even both. We are discussing matters that produce major ecological change and major ecological change that may not be easily reversed - may not be reversed at all. Action taken or not taken now can have an effect in 20, 25 or perhaps 50 years. Any action taken now will affect or be affected by our whole energy strategy. If we wait for 100% evidence on a matter such as this, then we will wait a very long time, perhaps the 25, or 30 or 50 years. Frankly, I don't think that 100% evidence is ever going to be available and therefore we have to act on the probable effect of processes that we understand only very incompletely.

I realise that some people will say "Ah yes, but the whole drive towards dealing with sulphur emissions from industrial plants has emanated from Germany because they are very worked up about the trees and so on, but we can show that forest die-back isn't purely to do with sulphur emissions". Well that is true up to a point. First of all you must not underestimate the importance of trees to the German national psychology and trees are extremely important in central Europe generally, if I can include Germany within central Europe. In any case trees are not the only reason for action. The 1972 Stockholm Conference, after all, pre-dated any concern that the Germans had about trees and I think that there are therefore other reasons for taking action.

The other thing is that one shouldn't ever say that because an effect is not measurable in rational terms it should be ignored. Politics is only occasionally rational and it is only occasionally, I suppose, undertaken by rational human beings. But we should not dismiss an argument because we cannot make the equations add up on both sides. It seems to me, therefore, that we have to act on the probable effect of processes that we do not understand completely and that we probably never will understand completely. If we do not act now on this particular matter it seems to me that we will bear a very heavy responsibility for future generations' capacity to enjoy life at all on this planet. I accept of course that it is not just a British problem, I accept even that it is not just a European Community problem. Much acid deposition inside the Community comes from Czechoslovakia, from East Germany and so on. All of that is true, but nonetheless, because of the importance of the Community in Europe generally, because of its economic importance, its political importance, its cultural importance, I think that any action by the Community is going to be extremely influential and therefore has to be encouraged.

Therefore I think the United Kingdom must move up from the back of the international pack. It must move to the front of the international pack. It must widen its rather narrow concern with the Public Sector Borrowing Requirement and it must recognise that we have to tackle problems even when their solutions do not look like being with us this side of the general election. Nonetheless, there are political imperatives that transcend even electoral victory. This is an important area of policy and I believe that the United Kingdom, inside the Community, has a tremendous responsibility and I think it ought to take that responsibility and deal more enthusiastically with it by supporting the general direction of Community policy at the moment. In other words I would like to see the UK embracing the current draft directive on major combustion plants and I would like to see us shaking off the image that we have in much of Europe so that I, in the European Parliament, can begin to feel proud of the fact that I am a British representative and not have to apologise for it all the time.

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AIR POLLUTION CONTROL – SITUATION REVIEWS
CHEMICAL INDUSTRY

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It has become customary, when talking about protection of the environment, to divide it into different categories: pollution of water, pollution of land by waste disposal, pollution by noise, and pollution of the atmosphere, which is what we are primarily interested in at this conference. Of these, I always think pollution of the atmosphere is the most important. After all, in normal circumstances, no-one is forced to drink polluted water but if someone's air supply is polluted it is a much more serious problem. All air in the open environment must be available for people to breathe and serious accidents involving the quality of air can have a devastating impact.

At any conference such as this in 1984, it is inevitable that you will be hearing many and perhaps even conflicting opinions about acid deposition. As far as we in the chemical industry are concerned, one thing is certain (and I believe it is accepted in all quarters), that emissions of $SO2$ and NOX from chemical plants contribute a negligible proportion of the total emissions of these gases to the atmosphere. Not only this, but over the years and particularly over the last 10 or 15 years, there have been substantial improvements within the industry. Design changes in new sulphuric acid and new nitric acid plants have resulted in reductions of the order of 80% in $SO2$ and $SO3$ (in the case of sulphuric acid plants) and 60% in NOx (in the case of nitric acid plants.)

The chemical industry, in common with other major energy using industries, is therefore concerned far more with watching what is going to happen to the cost of energy than with any direct impact on the design of chemical plants required by the problems of acid deposition. It is therefore not relevant, I feel, in a view on air pollution from the chemical industry, to trespass at a conference such as this into the whys and wherefores of acid deposition.

We in the chemical industry as a whole can certainly discharge a greater variety of materials to the atmosphere than any other collection of industries. These vary from the many hundreds of substances which make plants handling them registrable with the Health and Safety Executive, to the even larger number of plants which are not so registrable and which are subject to control by local authorities. From the point of view of industry, it is essential that there should be a clear realisation of the implications of the aims and consequences of air pollution control.

Historically, it can be shown that steps towards a cleaner environment have taken place in three distinct stages. These have been:

(1) the establishment and assessment of damage;

(2) the political decision on action;

(3) legislation and its implementation.

If we look back at the history of air pollution in the UK, and I know that the same is broadly true of other industrial countries in Europe, it is clear that in general the sticking point has been between stages (1) and (2). Evidence of damage due to air pollution going right back into the 19th century was very obvious. Many, who like me have reached their half century, can well recall the filthy smogs which inundated our major cities at regular intervals during the winter months with such obvious damage to health and to property. Most people would agree that up until the 1950s, the political decision for action was too slow.

The reason for this is perhaps rather academic but there is no doubt that it arose because of an apathetic public and the fact that controls on the emissions which gave rise to smog were either non-existent or were not in the hands of the experts in the Alkali Inspectorate.

Following the Clean Air Act of 1956 and subsequent amending Acts, the barrier between stages (1) and (2) started to come down. The 1956 Act had itself resulted from the publication of statistics showing that, in only one week in December 1952, over 4,000 people had died in London as a result of a combination of SO2 and particulates in the atmosphere, over and above those who would have been expected to die at that time. It is perhaps ironic that the major impact on public sentiment at the time was not that people were dying; it was that some prize cattle in London for the fatstock show were found to be dead in their stalls.

The action taken in the 1950s resulted from evidence that was quite irrefutable that there was air pollution and that this was killing people. Assessments were also made about the damage being done to buildings as a result of acid attack in our major conurbations. The figures were never seriously questioned and whatever the exact accuracy of the assessments, the facts were considered proven. Indeed, the need for action was so evident that stage (2) (ref. above) became comparatively unimportant. Once the facts in (1) were established, stage (3) followed. There was of course discusstion on means but not on the basic need.

It seems clear that the same pattern in the trends towards cleaner air is discernible today but I feel that there is a drift in that the barrier between stages (1) and (2) has declined to an undesirably low level. Indeed, I think that political decisions are now being made on the basis of very imprecise and sometimes non-existent signals coming up from stage (1). The public, far from being apathetic, is being influenced by news media which does not really set out to educate the public but rather to arouse public indignation. There are now votes for those who impose controls which purport to reduce pollution. Objections to such controls are usually confined to those whose interests will be directly damaged by them and their views are, not unreasonably, regarded as biased.

This unquestioning drift towards stricter and stricter controls for their own sake (and in some cases in the absence of any credible evidence of need) is something which must not be allowed to get out of hand. We hear a lot those days about "Pollution Prevention Pays". No doubt this is sometimes true but it is not a thesis which must be taken as an absolute truth without limit. The imposition of environmental costs on industry certainly reduces profits. This in turn reduces a company's ability to expand by building new plants, so increasing unemployment. If there really is an environmental advantage, if people's health is really improved, if people can live a happier, more pleasant life, then the imposition may be and up to now usually has been worthwhile. However, the concept that "Pollution Prevention Pays", if applied without due consideration for the facts, becomes very much a case of paying large numbers of people to dig holes in the ground and then paying an equal number to fill them in again. This may be profitable for those doing the work but it is certainly not profitable for the community. In the same way, the building of plants to reduce emissions to the atmosphere may be profitable for those building the plants but unless there is a clear advantage, and a reduction in environmental damage results, then the expenditure will represent a worthless cost to the community for which it may pay very dearly.

At a time when most of the obvious steps to clean up our environment have either been taken or are irrevocably committed, it is essential for the public to understand the implications and to determine, as is proper in a democracy, how much further it wants to go. The real decisions which must now be made are less obvious than in the past: whether it is better to live beside a river which smells occasionally in summer and which supports no fish and by so doing to enjoy roast beef for dinner on Sunday or, on the other hand, to live beside a river which never smells and can always support fish and have to make do with sausage and mash on Sunday. Even more poignant is the choice between living near a plant which sometimes smells and keeping a job; or living on the dole near to the place where the smelly plant used to be and importing its products from some undeveloped country.

Ever since the Alkali etc. Works Regulation Act of 1906, the policy of the Alkali Inspectors over the years has been based on the concept of "Best Practicable Means". This concept, as Lord Ashby has revealed in his excellent book "The Politics of Clean Air", was used in local enactments right back into the first half of the last century. It is a term which can be interpreted in many ways and in spite of its undoubted imprecision it has served the interests of preventing air pollution very well indeed. What it really means is, "You do the best which you reasonably can". Under conditions where even the best was unlikely to result in ideal conditions in the atmosphere of industrial areas, "doing the best you could" was probably an acceptable aim. Unfortunately, the legislation did not, and in its modern form does not, make it clear that the application of BPM should only follow from the indication of a definite need. So far, this open ended application of BPM, irrespective of need, has not given rise to too many problems. The potential, however, for unnecessary damage to industrial and therefore to national interests is there and the requirement for a need should, in my view, be built more firmly into the legislation.

The conclusion that I personally have drawn from the present situation is that the fixed emission standards for new plants which have resulted from the application of BPM may have to be re-examined to allow for present conditions. In another area of pollution control, that of water pollution, we in the UK are continually arguing in Brussels that all discharges to natural waters should be controlled on the basis of water quality standards. That is, you define the use to which the receiving waters will be put, you determine the analytical requirements to permit such use and then and only then do you determine the level of effluents that may be discharged into that water by the various dischargers. These of course may well be different in different locations.

I can see no reason why more aspects of this approach should not be built into controls on emissions to the atmosphere in this country. To be fair, the present policy of BPM does not in itself include the question of the height of the stack through which the discharge ordained by BPM should be released. This is a factor which is of course under the control of the Industrial Air Pollution Inspector and it is used by him to allow an element of variation depending on the nature of the site involved. Nevertheless, it would be desirable to calculate necessary controls on the basis that all parameters are variable and that the only argument for control is the impact on the environment at each and every particular site.

The concept of different emission standards, even for new plants emitting to the atmosphere, can raise the problem of fairness to those concerned. Despite the problems of acid deposition, it is a fact that most problems arising from air pollution are local and certainly in cases where the pollution problem concerns a non-toxic odour, it can be assumed that once dilution has rendered the material undectable to the human nose, the problem is over. It is also a matter of experience that the degree of odour which the public will tolerate without complaint is much less in or around a residential area than in other locations. While one can be sympathetic to those in industry who find themselves at a disadvantage as a result of the application of variable controls based on need, any effort to influence environmental thinking on fairness must inevitably lead to waste. It can never be justifiable to force an industry to install expensive equipment to reduce its discharges just because, somewhere else in a similar industry finds itself in an unfavourable location. A bad odour in Kensington must be more serious than one high up in the Pennines; this fact should be accepted and concepts of fairness should not be allowed to bias environmental thinking.

At this point, I should say something about EEC policies. So far, environmental legislation from Brussels has been in the form of Directives and as such has always been implemented at national level, through national legislation. For this reason it is impossible to tell what influence the EEC has had on Member States because it can always be argued that even if the UK, for example, had not been a member of the EEC, much of the legislation introduced in the UK since 1973 would have been introduced anyway. How true this is nobody can tell. Probably, the impact of EEC Directives on air pollution has been less than in the case of water pollution and the disposal of waste.

Air pollution is, however, within the programmes agreed by the Council of Ministers, and through them, Member States have accepted that controls should be based on a definition of ambient air quality standards at community level. This would appear to be at variance with the concept of BPM, which, within the limits already discussed, defines, usually, standards for discharges.

So far, Directives have been accepted by the Council of Ministers on SO2 and smoke levels in the atmosphere, and on airborne lead compounds. More recently, a Directive on the combatting of air pollution from industrial plants has been agreed by the Council; the wording is, however, very general, and it is not clear that it contains any impositions on the UK which are not already covered by existing legislation.

One thing we must be very vigilant about, however, is the Brussels Commission's attitude to the meaning of fairness. Most of the difficulties arise from the Treaty of Rome, on which all EEC activities must be based. This does not include any articles specifically defining the powers or the duties of the Community to protect the environment. This gap in the Treaty has been circumvented by the Commission, in sending proposals for environmental directives to the Council with the justification that they are covered by either Article 100 or Article 235.

Article 100 says that

"The Council shall, acting unanimously on a proposal from the Commission, issue Directives for the approximation of such provisions laid down by law, regulation, or administrative action in Member States and directly affecting the establishment or functioning of the Common Market."

There is no word of the environment there, merely the general intention of securing fairness for all.

Article 235 reads

"If action by the Community should prove necessary to attain in the course of the operation of the Common Market one of the objectives of the Community, and this Treaty has not provided the necessary powers, the Council shall, acting unanimously on a proposal from the Commission, and after consulting the Assembly, take the appropriate measures."

Consideration of the wording of Article 235 may indicate that it can be used to introduce both Directives and Regulations aimed at providing a cleaner environment. The interpretation of Article 100, however, is usually that a Directive (and in that case it can only be a Directive, and not a Regulation) may be proposed to prevent any Member State doing anything that would give it an unfair economic advantage over other Member States. As applied to the protection of the environment, this would automatically require a definition of what is unfair. Does it mean that no Member State shall be allowed to enjoy an economic advantage by allowing its environment to become more polluted than the environment of another Member State (and I think most of us would say that that was quite reasonable) or does it simply mean that in order to prevent any advantage to any industry because of its location, all discharges of materials, whether to land, water or to the atmosphere, should be the same, irrespective of whether there is any environmental need?

Turning finally to the future, it must be said that industry views the development of air pollution control legislation with considerable apprehension. I have already discussed some of the basis of this fear, but wish now to deal specifically with the future of the Industrial Air Pollution Inspectorate. The origin of our apprehension lies in the issue of a report by the Robens Committee in 1972. Lord Robens and his Committee had been charged to advise the Government on future policies to secure the health and safety of the people at work. The Committee pointed out that there were no fewer than 9 separate groups of health and safety statutes, dealing respectively with factories, commercial premises, mining and quarrying, agriculture, explosives, petroleum, nuclear installations, radioactive emissions and alkali emissions. The addition of the last two to the list was anomalous, since those Inspectorates (and the Committee did not seem to have fully understood what the Alkali Inspectorate's function was) were not solely concerned with the protection of the health of people in the workplace. Their role was the protection of the environment at large. Indeed, the Robens report admits that the "treatment of the last two Inspectorates raises issues going beyond our terms of reference."

In its recommendations, the Robens report gave many examples of how the work of the various Inspectorates, existing in 1972, could overlap with each other. While many of those examples were impressive, this was emphatically not the case where examples of the work of Alkali Inspectors was included.

Following the publication of the Robens report, the Heath Government published its "Health and Safety at Work" Bill from which it was clear that the Government intended to include the Alkali Inspectorate within the new Health and Safety Executive which it intended to establish. This met considerable resistance both from within industry and from the Alkali Inspectors themselves. There is reason to believe that the then Secretary of State for the Environment, Mr. Geoffrey Rippon, was against the inclusion of the Inspectorate within HSE, but that he was over-ridden (possibly at Cabinet level).

Following a change of Government, the new Environment Secretary, Anthony Crosland, wrote to the then Chairman of the Royal Commission on Environmental Pollution, Sir Brian Flowers, suggesting that the Royal Commission might consider the subject of air pollution control, and in particular, make recommendations on the future of the Alkali Inspectorate. However, within a few weeks of this request having been made (in 1974), the Health and Safety at Work Act received the Royal Assent, so that without waiting for the comments of the Royal Commission, the Alkali Inspectors found themselves under the Health and Safety Executive. An undertaking was given at that time that no irrevocable steps would be taken to incorporate the Inspectorate under the new HSE until the views of the Royal Commission were known.

In January 1976, the Royal Commission published its 5th Report. This included, inter alia, its views on the Alkali Inspectorate. These were very definite, and included the statement:

"We accordingly recommend that the Alkali Inspectorate should be removed from the Health and Safety Executive forthwith, and should return to the control of the Department of the Environment."

It is worth noting that throughout this entire period the Confederation of British Industry (CBI) has made known its view that the Alkali Inspectorate should be returned to the Department of the Environment. The CBI were very pleased with the Royal Commission's report.

For a number of years after 1976, the matter was still in doubt. It was not until the Government's response to the 5th Report was finally before Parliament in 1982 that it was formally confirmed that the Inspectors would be a permanent part of HSE. This was greeted with almost universal dismay, firstly within the ranks of the Inspectorate itself, but also by other outside bodies. The then President of the National Society for Clean Air, The President of the Confederation of British Industry, and the President of the Institution of Environmental Health Officers, sent a joint letter to Mr. Heseltine deploring his decision and drawing his attention to the report which the Royal Commission had issued, at a former Secretary of State for the Environment's request six years earlier.

The Environment Committee of the Chemical Industries Association, of which I was and still am a member, and which could speak for 99% of the chemical industry, unanimously agreed to give full support to the CBI's call for the Inspectorate to be returned to the Department of the Environment.

One of the great mysteries of all this, which may eventually be solved, concerns the origin of the political pressure which induced both Labour and Conservative administrations, and Mr. Heseltine in particular, to reject what appeared to be the unanimous advice of all those who were in the best position to know. I can confirm that UK industry will still seek to use every avenue open to it to have this decision reversed. We greatly welcomed the strongly worded comment by the present Royal Commission on Environmental Pollution in their most recent (tenth) report.

They stated that they still considered that the transfer of responsibility for the Alkali Inspectorate, from the Department of the Environment to the Health and Safety Executive, has been misconceived.